Sky and TELESCOPE

of Washington

Stars for November

In Focus

BEGINNING with this issue, the pictures of celestial objects that have appeared on the back cover for 12 years will now be placed on inside pages of the magazine. This change has been advocated by many readers; there will be less risk of damage in mailing. Also, it will provide for the occasional use of larger engravings (as in this issue) which will often be required to do justice to the large Palomar photographs that are now becoming available. (The center picture is easily removed for preservation by loosening the staples.)

This month's center picture is an enlargement of a photograph of the great spiral nebula M101, NGC 5457, obtained with the 200-inch Hale reflector. The wealth of intricate detail represented is in vivid contrast to Méchain's description of this object, which he discovered in 1781, as obscure and featureless.

Like the better-known Triangulum galaxy, M33, which it closely resembles, M101 has well-opened spiral arms; both objects belong to type Sc in Hubble's system of classification. On the revised scale of intergalactic distances, M101 is about six million light-years from us. Situated in Ursa Major at R. A. $14^h\ 1^m.4$, $+54°\ 36'$ (1950), this nebula covers an area on the sky comparable to that of the full moon, and is of total apparent magnitude 9.

One supernova has been discovered in M101, by Max Wolf on Heidelberg Observatory plates in 1909. While the brightest recorded magnitude of this supernova was +13.3 on the international photographic scale, the observations were so scanty that the true maximum may have been somewhat brighter than this. As early as 1917, Ritchey at Mount Wilson found three ordinary novae in the system.

For studying the structure of spiral galaxies, M101 offers many advantages. A nearby galaxy, it is conveniently resolved into stars with the 200-inch telescope, which shows a profusion of gaseous nebulae, clusters, and star clouds, and the arrangement of the whole is the more easily made out because the system is seen full-face.

THE INDEX TO VOLUME XII

appeared in the October *Sky and Telescope*. Indexes to Volumes I through IX are available, at 35 cents each postpaid. The indexes for Volumes X and XI are included in the issues of October, 1951 and 1952, respectively.

BINDERS

for *Sky and Telescope* are available. These are of the loose-leaf type, in which each issue may be filed as it is received. Covered with dark blue fabrikoid, the binders may be reused from year to year or kept as permanent binding for separate volumes. Each binder costs $3.50 postpaid in the United States, $4.00 in Canada. No orders from foreign countries can be accepted. Your name can be goldstamped for 70 cents extra, the volume number for 40 cents, both for $1.00; print desired lettering clearly. Payment must accompany your order.

SKY PUBLISHING CORPORATION

Sky and TELESCOPE

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SYMPOSIA IN BOSTON

When the American Association for the Advancement of Science holds its Christmas meetings in Boston this year, numerous papers of interest to astronomers will be included in the program. Dr. Charlotte Moore Sitterly, of the National Bureau of Standards, will give the address of the retiring vice-president of Section D (astronomy), on Sunday, December 27th.

A symposium on current progress in radio astronomy is being sponsored jointly by Section D and Section B (physics), beginning on Saturday afternoon, with papers by Dr. John P. Hagen, Naval Research Laboratory, on the sun; Dr. Peter M. Millman, Dominion Observatory, on meteors; Dr. Harold I. Ewen, Harvard Observatory, on 21-cm. radiation from the Milky Way; and Grote Reber, on galactic and extragalactic radiation. On Sunday there will be a panel session on current research projects at home and abroad in which several foreign scientists will participate.

Another AAAS symposium on December 30th will deal with the origin of meteorites. Drs. Harold Urey and Harrison Brown, of the University of Chicago, and Drs. William H. Pinson and H. H. Uhlig, of the Massachusetts Institute of Technology, will participate.

PERKINS DIRECTOR

Dr. Geoffrey Keller, who has served as acting director, has been appointed director of the Perkins Observatory at Delaware, Ohio, which is jointly operated by Ohio Wesleyan and Ohio State universities. The observatory's 69-inch reflector is the fourth largest in this country. Dr. Keller is well known for his research in the fields of stellar constitution and astronomical seeing.

VOL. XIII, NO. 1 — NOVEMBER, 1953

CONTENTS

COVER: The Sommers-Bausch Observatory of the University of Colorado, dedicated August 27th at the 89th meeting of the American Astronomical Society, houses a 10½-inch Bausch and Lomb refractor. Any of the five pairs of doors covering the slit in the aluminum dome may be electrically opened and closed without disturbing the others. The entrance to the observatory is to the right; the lecture room is in the foreground, and offices are on the far side of the building. The architecture is adapted rural Italian, in the same style as other buildings of the university. The view is to the southwest, across Boulder toward the Flatirons of the Rocky Mountain front range, with the campus below and to the right of the picture. University of Colorado photograph by Floyd G. Walters. (See page 3.)

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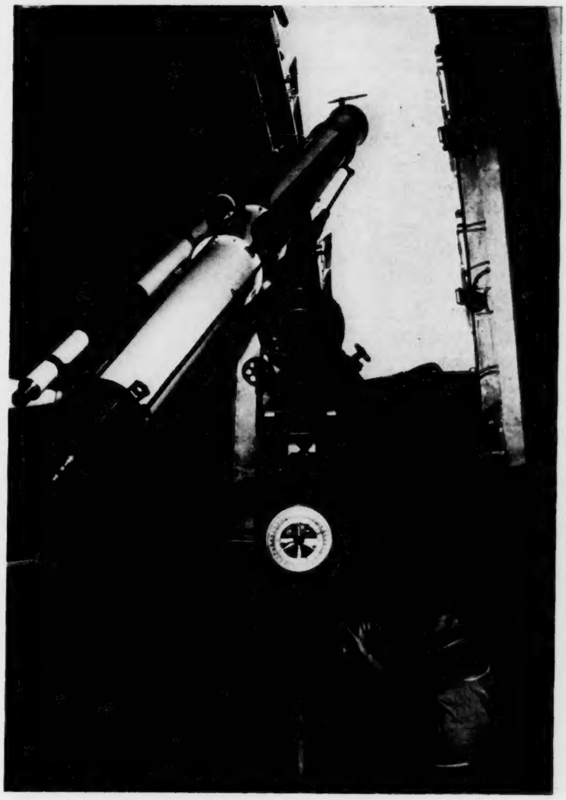
The principal articles in SKY AND TELESCOPE, beginning with Vol. XII, are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

Colorado Conclave

By C. M. Huffer, *Washburn Observatory University of Wisconsin*



The 10½-inch refractor of the Sommers-Bausch Observatory, at the University of Colorado. The tube is 17 feet long, on a typical German or Fraunhofer mounting. The star-finder dials on the pier permit quick setting to any star when its right ascension is known. University of Colorado photograph by Floyd G. Walters.

THE 89th meeting of the American Astronomical Society, at Boulder, Colo., August 26-30, 1953, was probably the largest in the history of the society. At least it was the largest excepting those held with other organizations. In 1948 at Pasadena, 400 persons attended a combined meeting with the Astronomical Society of the Pacific, at which there was the added attraction of a trip to Palomar Mountain and a special dedication of the 200-inch telescope.

Certainly the program at Boulder was the largest, with 91 papers on the printed program and five additional ones at the end. However, the council of the society decided to favor those authors who were present, voting to read by title all papers by absent authors and all second papers by those who were present. This avoided simultaneous sessions, to which there is a great deal of opposition in the council, but caused considerable discussion in view of the desire of some people to hear omitted papers.

During the three-day program, about 70 papers were actually presented. These were arranged roughly in groups according to subject: photometry, spectroscopy, solar physics, theoretical astronomy, and assorted subjects. The 10-minute time limit was strictly enforced and the program was finished by the end of the scheduled time. All sessions for papers were held in the lecture room of the physics building of the University of Colorado, where more than 200 persons could be accommodated

The society had as its guests four astronomers from abroad: Sir Harold Spencer Jones of England, Dr. R. H. Stoy from the Cape of Good Hope, Prof. O. Heckmann from Germany, and, on the last day, Dr. A. Danjon from France. Several other foreign astronomers were also in attendance.

Our host was the High Altitude Observatory of Harvard University and the University of Colorado, which has its laboratories on the campus at Boulder and its main observing station at Climax, Colo.

The dedication ceremony of the new Sommers-Bausch Observatory in Boulder was one of the highlights of the meeting. Funds for the building (see the front cover) came from the estate of the late Mrs. Mayme Sommers, in memory of her husband, Elmer E. Sommers.

Dr. Walter O. Roberts and members of his High Altitude Observatory staff will operate the new observatory jointly with the University of Colorado. It will be used for public nights, and in connection with university courses in astronomy and astrophysics, soon to be initiated, and in the basic sciences. The High Altitude Observatory will use the telescope for sunspot and other solar observations. At present, efforts are being made to photograph rapid changes in solar granulation. In the room beneath the telescope are located the radio transmitter and receiver by means of which the researches of three solar observatories are co-ordinated: Boulder, Climax, and Sacramento Peak. The last, in New Mexico, is operated by the Geophysics Research Directorate of the Air Force Cambridge Research Center.

According to the records of the Bausch and Lomb Optical Company, the 10½-inch refractor was built in 1912 by George Saegmuller, a Bausch and Lomb designer, who designed other telescopes now in use at Denver, Georgetown, and Manila observatories. Until 1946, when it was turned over to the University of Colorado, the instrument was housed atop one of the tallest company buildings, and until World War II had been an attraction for Rochester visitors and for students at the University of Rochester.

The observatory was open for inspection on the afternoon of Thursday, August 27th, and the formal dedication exercises were held in the Macky auditorium that evening. This part of the program was open to the public, and several hundred persons were present who were interested in the University of Colorado and its program in astronomy. The history of the observatory was recounted by Ben F. Bennet, a close friend of the Sommers family, and by Dr. Donald H. Menzel, acting director of Harvard Observatory and a native of Colorado, who was instrumental in obtaining the telescope as a gift from Bausch and Lomb.

Following the dedication exercises, the Astronomer Royal gave his well-known popular address, "Is There Life on Other Worlds?"

A second highlight of the meeting was the symposium on the origin of cosmic rays, followed by the Russell lecture by Dr. Enrico Fermi, University of Chicago, on "Galactic Magnetic Fields and Cosmic Rays." The symposium, on the afternoon of Friday, August 28th, had as its chairman Prof. C. L. Critchfield, of the University of Minnesota. The first speaker was Dr. R. W. Williams, Massachusetts Institute of Technology, whose subject was, "Constitution, Energy and Time-Variations in Primary Cosmic Radiation — A Summary of the Observed Phenomena." The material of this talk, intended to lay the foundation for the succeeding papers, was as complicated as its title. It left the listener with the impression that the physicists know a great deal about the nature of cosmic rays, but that they need to come to the astronomers for assistance concerning the source and means for production of the rays.

The second part of the symposium

was devoted to theories of the origin and variations in primary cosmic ray radiation. Dr. Menzel discussed the sun as a source of primary radiation and showed motion pictures of solar prominence activity. He was followed by Dr. S. A. Korff, New York University, who spoke on the "Effects of Cosmic Ray Neutrons," and Prof. Marcel Schein, University of Chicago, whose subject was "Origin Beyond the Solar System."

Then came the third part of the symposium, the discussion from the floor. Two well-known physicists, Dr. Fermi and Dr. Edward Teller, of the University of California, were in the audience, and the first questions were directed toward them. There did not seem to be any agreement regarding the nature of about 10 per cent of the cosmic rays, but the discussion was lively and stimulating, and it was interesting to hear the different points of view, especially between the physicists and the astronomers concerning the part played by lithium, beryllium, boron, and some heavier elements in the production of cosmic rays. The average listener was left with the feeling that a great deal of work is still necessary before a satisfactory theory of the origin of cosmic rays will be adopted. Astronomers owe a great deal to physicists for their part in this important research, and the astronomers present at Boulder are indebted to the physicists present for a lesson in the enthusiastic presentation of papers.

After having been introduced to the personality of Dr. Fermi in the afternoon, we were prepared for an interesting and lively lecture in the evening, and were not disappointed. The Russell lectures, which were set up by the society in 1946 in honor of Prof. Henry Norris Russell, are the most important addresses at our meetings. This was the sixth in the series and the first to be given by a speaker who is not primarily an astronomer. But since there is a close correlation between astronomy and cosmic rays, it was particularly appropriate to ask a physicist to speak on this subject.

That there are magnetic fields in the stars and in the galaxy has been known for several years. That there is a connection between these magnetic fields and the phenomenon of cosmic rays is new and open to discussion. Dr. Fermi considered the possible correlation, and also attempted to explain the large energy involved. He spoke from notes (without a manuscript), and it was fascinating to follow the development of his thought, which he clarified by dramatic illustrations with the use of his hands. We had decided beforehand that even if a listener were unable to follow the arguments he would be interested in the speaker and his platform manner. We hope other speakers outside the membership of the society will be invited for future lectures. Dr. Fermi's talk will be published in the *Astrophysical Journal.*

This meeting was one of very few without formal social events. While there was the usual society dinner on the last evening, there were no teas nor receptions. It had been intended to have a tea in connection with the dedication of the observatory, but the crowded program made this impossible. Since nearly everybody was staying in the university dormitory, there was plenty of time for social activity without formality. We ate three meals together each day, and talked in the rooms, in the corridors, outside the building, and at little informal parties. The nonastronomical ladies, as usual, had more fun than the men, having morning coffee together and a trip to historic Central City. We should mention that the hard-working council managed to take a couple of hours off their first evening for a steak dinner at the Alps Club in Boulder Canyon.

At the Masonic Temple Saturday evening, 200 persons attended the dinner served by the ladies of the local Masonic organizations. Twenty members and guests sat at the speakers' table, including President Robert R. McMath, who presided and introduced the program.

Dr. Raymond J. Seeger, of the National Science Foundation, informed us that the foundation has funds for astronomy, but that we must ask for them. Information concerning the filing of applications for grants has been sent to all members.

Following brief remarks by Sir Harold and Dr. Danjon, Dr. Heckmann read a letter written by Wilhelm Struve in 1837 to the famous maker of astronomical instruments, Ritter von Utzschneider, in Munich. This original letter was then presented to Struve's great-grandson, Dr. Otto Struve, director of the Leuschner Observatory, University of California, who is a collector of old books and documents. Dr. Struve commented on the early history of stellar parallaxes in connection with the work of Wilhelm Struve, and then talked about the International Astronomical Union, of which he is president, and the plans for its next meeting, to be held in Dublin in 1955. It is hoped that many Americans will go to Dublin, and that funds can be obtained to enable young astronomers to travel there.

The Boulder meeting ended with a trip to Climax and the coronagraph station there. This journey was made by bus and private automobile. Since the altitude is over 11,000 feet, plans were made to keep the visitors a comparatively short time. A picnic lunch was served; the observatory's coronagraph provided a view of some solar prominences; and the early stages of a new building to house a large coronagraph were inspected. The scene was enhanced with a typically pure blue sky.

The next meeting of the American Astronomical Society will be held in Nashville, Tenn., in December. In June, next year, our meeting at Ann Arbor, Mich., will precede the eclipse of June 30th by about one week. It is possible that the eclipse will be an attraction which would make the Ann Arbor meeting even larger than the Colorado conclave.

Ed. Note: The group photograph of the Boulder meeting, with an identification key, will be published in the December issue.

ASTRONOMY AT ILLINOIS

Extensive reorganization of the department of astronomy at the University of Illinois has followed the appointment of Dr. G. C. McVittie, Queen Mary College, London, as department head in August, 1952. The transit circle and 12-inch refractor have been completely renovated and modernized by J. W. Fecker, Inc. The 4-inch Ross camera will be moved to a new site remote from artificial lights.

Dr. Stanley P. Wyatt, Jr., formerly of the University of Michigan, has been appointed assistant professor, and under him observational astronomy will be taught again on a regular basis, although the teaching of astronomy at Illinois emphasizes theoretical subjects. A new course leading to the degree of M.S. in astronomy includes celestial mechanics, stellar structure, relativity theory, and the elements of dynamical meteorology. In the future, it is planned to add astrophysics to the master's degree and to institute a Ph.D. degree in theoretical astronomy.

LETTERS

Sir:

Since the publication of my article on "Sah and Sopdet" in the February, 1953, **Sky and Telescope**, there has appeared a magnificent edition, in English, of **The Pyramid Texts,** by Samuel A. B. Mercer, of the University of Toronto. He interprets "the Pointed One," as the translation of **Sopdet,** to mean "the preeminent, gifted, or superior, one." I accept this meaning on several grounds; and it is unnecessary, therefore, to assume any foreign influence in the origin of the name.

GEORGE A. DAVIS, JR.
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Sir:

Credit should be given to the Rev. Dr. Isaac Watts for the sundial motto given at the conclusion of the article on sundials, July, 1953, page 232.

SAMUEL G. BARTON
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Philadelphia 39, Pa.

American Astronomers Report

Here are highlights of some papers presented at the 89th meeting of the American Astronomical Society at Boulder, Colo., in August. Complete abstracts will appear in the Astronomical Journal.

Chromospheric Temperatures

Observations in the hydrogen Balmer continuum and in the Balmer lines themselves should provide independent values of electron density and electron temperature in the solar chromosphere. The High Altitude observations at the 1952 Khartoum eclipse, under the leadership of Dr. John W. Evans, now director of Sacramento Peak Observatory, were planned to exploit new methods of analysis of eclipse data developed several years ago by Dr. R. N. Thomas, of Harvard Observatory.

During the summer of 1953, at the High Altitude Observatory, under Dr. Thomas' guidance, R. G. Athay, D. E. Billings, D. L. Dimock, S. Matsushima (University of Utah), and C. A. Whitney (Harvard Observatory), pooled their efforts in measuring and interpreting flash spectrum plates taken at Khartoum. From relative intensities of the continuum at 3647 and 3700 angstroms, just above and below the Balmer continuum limit, they were able to set upper and lower bounds to the electron density and kinetic temperature gradients in the chromosphere.

Beginning with a point 500 kilometers above the edge of the sun at eclipse (which is, in turn, 500 kilometers above the sun's photosphere at the center of the disk), they find the temperature must increase at least from 9,600° absolute to 25,000° at a height of 2,200 kilometers. The electron density drops in this same distance from $10^{11.8}$ to $10^{11.4}$ electrons per cubic centimeter. These values confirm previous high estimates of chromospheric temperatures published by several astronomers, in contrast with low-temperature models of the chromosphere generally accepted in the past.

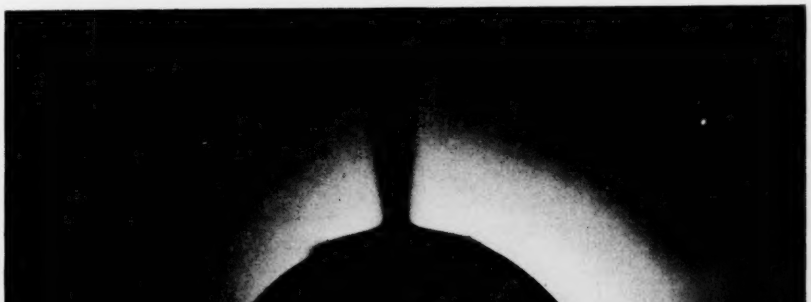
Moon-Position Camera

Observations of the position of the moon are of increasing importance in practical problems, such as determining the size and shape of the earth and tracing fluctuations in the length of the day. But the motion, brilliance, and size of the moon have hitherto prevented our developing an accurate photographic technique for routine measurements of its position with reference to the stars. The chief practical difficulty in photographing the moon and the surrounding star field simultaneously has been that the rapidly moving moon makes an unmeasurable trail during the time required for the stars to register.

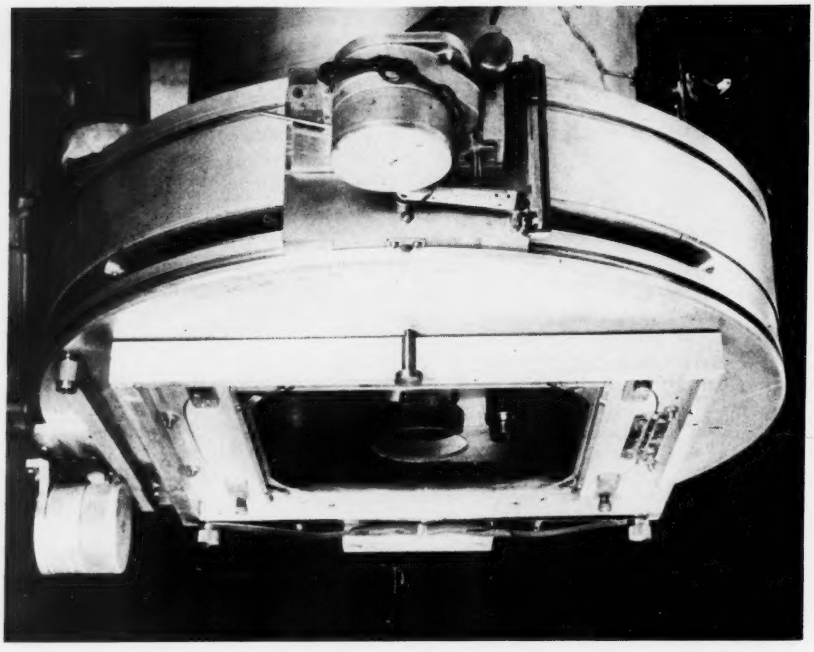
A new attack on the problem was reported by Dr. William Markowitz, who has constructed a special moon-position camera for use on the 12-inch refractor of the U. S. Naval Observatory. The unique feature of this device is a dark glass plane-parallel filter about two inches in diameter that intercepts the moon's image and reduces its intensity so that the moon is not overexposed in relation to the stars. Most important, however, is that tilting the filter shifts the image of the moon, so that tilting at the proper rate by an electric motor holds the moon stationary with respect to the star images during the exposure.

The stars are photographed through a yellow filter (Schott GG-14A) on a 7-by-7-inch plate. This filter, of nearly the same thickness as the dark moon filter, has a central hole of the dimensions of the latter. At the instant when the dark and light filters are parallel, there is no displacement of the moon relative to the stars, and this moment is recorded by an electrical contact, giving the epoch of the observation. Exposures range from 12 seconds with Eastman II-G emulsion at full moon to about 20 seconds with 103-G at the quarter phases.

To obtain precision tracking of the stars, the driving clock of the 12-inch telescope is not used, but a moving plate carriage is driven at the sidereal rate by a micrometer and synchronous motor. This precision drive eliminates magnitude effects among the stars due to improper guiding. Either three or four plates are taken at one time, and the best two of these are measured. Observations can be



In this moon and star field, photographed with the Markowitz camera, many more stars can be recognized on the original negative than the reproduction shows. Antares appears above and to the right of the moon. The lunar image is surrounded by the dark shadow of the tilting filter. North is at the top. U. S. Naval Observatory photograph.



The moon-position camera is here attached to the 12-inch refractor. The back of the plateholder has been removed to show the light yellow star filter, pierced by a central opening. Through this can be seen the tilting moon filter. The synchronous motors used for the precision drive and to tilt the moon filter are above and to the left. U. S. Naval Observatory photograph.

made rapidly; four plates are taken in five minutes, and only about 15 minutes need be spent in the dome.

Regular observations of the moon's position have been made with the Markowitz camera since June, 1952, and the results are most encouraging. From a single plate, the internal probable error of the moon's position is only 0.15 second of arc in right ascension and 0.10 in declination. These photographs can be taken at any phase of the moon, except within a few days of new, and good results are possible under only fair observing conditions and at rather large zenith distances. The camera can be used on refractors of 8-inch aperture or larger, with focal lengths as short as 80 inches.

An international program is being planned for co-ordinated observations of the moon with Markowitz cameras at several observatories in widely separated parts of the world. Among the useful results will be improved determinations of the lunar parallax and the elements of the moon's orbit, of the dimensions and shape of the earth, and of irregularities in the earth's rotation.

Epsilon Aurigae

The remarkable eclipsing star Epsilon Aurigae undergoes minima of 700 days' duration at intervals of 27 years. The approach of the next eclipse, in the years 1955-57, is attracting increasing attention to the variable. Dr. Zdenek Kopal, of the University of Manchester, England, proposed a new theory to account for one of Epsilon Aurigae's most puzzling features. This is the fact that the light of the brighter component, of spectral type $cF5$, continues to shine during the eclipse, merely getting about 0.8 magnitude dimmer without change in quality during the minima. The companion that causes the eclipses must be both invisible and semitransparent.

A proposal by Kuiper, Struve, and Stroemgren, in 1937, was that the companion is a huge star, too cool to be seen by its own light, but surrounded by a dense layer of free electrons; when the *F* star passes behind such a layer, its light should be dimmed. Dr. Kopal remarks that this explanation has many difficulties, in particular that it would cause a rounded minimum instead of the flat-bottomed light curve actually observed.

Dr. Kopal advances the alternative suggestion that the eclipses of the *F* star are caused by the interposition of a flat ring of solid particles surrounding the invisible companion. He said, "Such a ring (of which Saturn's rings may represent a small-scale model) may well be semitransparent; and it goes without saying that an eclipse by it should be capable of producing a perfectly flat minimum." He estimates roughly that the mass of the ring should be between 10^{27} and 10^{28} grams, of planetary rather than stellar order, and that its dimensions cannot be much less than the confines of our solar system.

Magellanic Cloud Distances

A new determination of the distances to the Large and Small Magellanic Clouds is being carried on by Dr. Harlow Shapley, of Harvard Observatory. In each of seven globular clusters in the Large Cloud he measured the apparent magnitudes of 30 to 40 of the brightest nonvariable stars. By comparison with the bright stars in the globular clusters of our own Milky Way system, whose distances are relatively well known, he finds that the distance modulus of the Large Cloud is 19.05 magnitude, with an internal mean error of less than 0.1 magnitude. This result, after correction for space absorption of 0.4 magnitude, puts the distance of this neighbor galaxy at 175,000 light-years. An analogous study of stars in three globular clusters in the Small Cloud is not complete, but points toward a similar result.

This work gives a factor of 2.2 for the correction of our former estimates of distances to other galaxies, when these are based on apparent brightnesses of classical Cepheid variables. In 1952, Dr. Shapley determined the Magellanic Cloud distances by comparing the total magnitudes of their globular clusters with the magnitudes of globulars in our own galaxy, obtaining a factor of 2.0 to the old distance scale. Both results are in substantial agreement with H. Mineur's earlier analysis of the proper motions and radial velocities of the classical Cepheids.

Spicules and Granules

At the High Altitude Observatory, Drs. J. H. Rush and W. O. Roberts have analyzed two film sequences of spicules at the south polar zone of the sun, taken in 1949 with the Climax coronagraph in hydrogen-alpha light. These films were run at six frames per minute for a combined duration of 92 minutes. Both films indicated that on the entire sun at any given moment there are up to 22,000 spicules having lifetimes of 3/10 minute or greater, assuming that they are distributed generally and at random over the solar surface. For 400 spicules, lifetimes averaging about four minutes were determined, confirming a value obtained by Dr. Roberts in 1945. Nearly all spicules were radial to the sun, and the upward speeds of 64 of them ranged widely about a mean of 32 kilometers per second. Apparent downward displacements were observed in many cases, but it is not known whether these were the result of actual return of material to the sun.

Evidence that the small, bright granules seen on the sun's photosphere in white light are, in general, ascending from its surface has been found by F. E. Stuart and Dr. Rush. They used

(Continued on page 14)

NEWS NOTES

By Dorrit Hoffleit

A HOTTER FLAME

In December, 1951, we reported on measurements by Raymond H. Wilson, Jr., University of Louisville, and his former associates at Temple University of the "Hottest Flame on Earth," fluorine burning in hydrogen. Dr. Wilson now informs us that its temperature has been exceeded by cyanogen burning in pure oxygen. In a 50-50 mixture at atmospheric pressure, its temperature has been measured at $4{,}640^\circ \pm 150^\circ$ absolute, which is over 300 degrees hotter than the fluorine-hydrogen flame at the same pressure.

The work was carried out at the Research Institute of Temple University, as before in collaboration with J. B. Conway, of Villanova College, and A. V. Grosse, of the institute. A special report has been made to the Office of Naval Research under Contract No. ONR-N9-87301, and a brief summary for chemists has appeared in the *Journal* of the American Chemical Society, *75*, 499, 1953.

Dr. Wilson worked especially on the astronomical part of the experiment, comparison of the solar spectrum with that of lithium introduced into the flame. He writes, "Compared to the fluorine-hydrogen flame, that of cyanogen and oxygen is very gentle and well behaved. It reminds one of peaches and cream, not only by its beautiful yellow-pink color, but also by its odor, since traces of the deadly hydrocyanic acid are essences of peach and almond flavors."

In a recent exhaustive search through *Chemical Abstracts,* Dr. Grosse found that the solar line-reversal method, independently developed by the group at Temple, had been applied by two German chemists, von Wartenberg and Reusch, to the problem of the atomic hydrogen flame. They reported their work in 1934 to the Goettingen Academy of Sciences, but this application of solar astronomy to chemistry has not hitherto received general attention.

An important result of the direct measurement of the temperature of the cyanogen-oxygen flame is more accurate knowledge of the dissociation energy of the nitrogen molecule, N_2.

RADIO ASTRONOMY IN THE TROPICS

In January, 1952, the University College of the Gold Coast started the erection of a radio astronomy observatory at Achimota, near Accra in west Africa. This geographical location offers the advantages that nearly the entire sky is accessible, and the sun passes near the zenith throughout the year. In the tropics, however, climate and weather introduce handicaps not encountered in more temperate regions. A report in *Nature* by Professor H. E. Huntley, of the University College, mentions the precautions that must be taken against white ants which attack all wooden parts, and against the underbrush which threatens to engulf the ground plates. In the rainy season there is danger of flooding electrical parts during frequent tropical storms, when the record of lightning flashes is nearly continuous.

Nevertheless, remarkable results are already being obtained at Achimota. From hour-to-hour recordings of radiation received from radio stars, it has become clear that at certain seasons F-layer disturbances are more frequent in the tropics than in other latitudes. At times these disturbances are so marked that they obliterate signals as strong as those from the conspicuous radio star in Virgo. Future work at the Achimota observatory is planned to measure the co-ordinates of radio stars close to the celestial equator.

1,026 STELLAR ORBITS

A general catalogue of approximate orbits about the galactic center has been published by Karl Schuette, of the Munich Observatory, for stars known to be within about 100 light-years of the sun. Adequate data were available for 1,026 stars. The computations are based on the assumption of simple two-body Keplerian motion. In such a case the only data required for any star are its coordinates in the galactic system, the three components of its velocity, and the orbit of the sun about the galactic center. Schuette assumes that the sun is 10,000 parsecs from the center and moves in a circular orbit with a velocity of 268 kilometers per second. The discussion of the orbits will appear in a future publication.

It is interesting to find only one possibly hyperbolic orbit among the 1,026. A year ago Joyce Marrison Newkirk, in a Harvard Observatory *Bulletin,* published galactocentric orbits for 50 cluster-type variable stars. These are Population II stars, for the most part between 500 and 2,000 parsecs from the sun. Among these she found five (or 10 per cent) to have definitely hyperbolic orbits. Schuette's stars, on the other hand, are mostly dwarf stars of Population I.

IN THE CURRENT JOURNALS

POWER FROM THE SUN, by Eric Hodgins, **Fortune,** September, 1953. "The sun offers to the earth a bounty, an inconceivable bounty, of a million trillion kilowatt-hours in the course of a year. . . . But some 120,000 trillion kwh becomes the means to the greatest mass-production phenomenon known to man, which man has contemplated, first stolidly, then with wonder, and today with respectful but utter helplessness."

WHERE DO COSMIC RAYS COME FROM? by Arthur Beiser, **Scientific Monthly,** August, 1953. "Perhaps in a way it is good that a puzzle of this magnitude still remains unsolved; certainly it prevents any complacency about the completeness of our knowledge of the universe we live in."

THE ORIGIN OF THE ATMOSPHERE, by Helmut E. Landsberg, **Scientific American,** August, 1953. "What it has evolved from and what it is changing to are matters for conjecture, with considerable leeway for scientific debate. But neither the first nor last stages of the Earth's atmosphere appear to be compatible with any life processes we know."

THE DISTRIBUTION OF INTERSTELLAR GAS

As soon as the coude spectrograph of the 200-inch telescope was put into operation, work was begun on the interstellar lines in the spectra of distant early-type stars in the northern Milky Way. Although the observing program has not been completed, Dr. Guido Muench, Mount Wilson and Palomar Observatories, has published some important preliminary results in the *Publications* of the Astronomical Society of the Pacific.

In general he finds that the interstellar lines for stars between galactic longitudes 65° and 130° and at about 2,000 parsecs from the sun consistently show two strong components of nearly comparable intensity. In some cases, these strong components are further resolved into more complex structures, some stars showing as many as seven lines. If the separations of the major components are attributed in the usual way to differences in radial velocity of the star and the intervening gas clouds producing the absorption, there appear to be two major concentrations of the gas. These correspond to the structural features of the spiral arms described by Morgan, Sharpless, and Osterbrock. This is welcome confirmation that the gas clouds are concentrated along the arms of the galaxy.

DEATH OF E. P. HUBBLE

The sudden death of Dr. Edwin P. Hubble on September 28th of cerebral thrombosis deprives American astronomy of one of its outstanding leaders. His work on extragalactic nebulae at the Mount Wilson and Palomar Observatories made him a foremost authority in this field. His principal contributions were establishment of the extragalactic nebulae as stellar systems, his studies of their distances and distribution, and his development of the law of the red shifts. He was 63 years old.

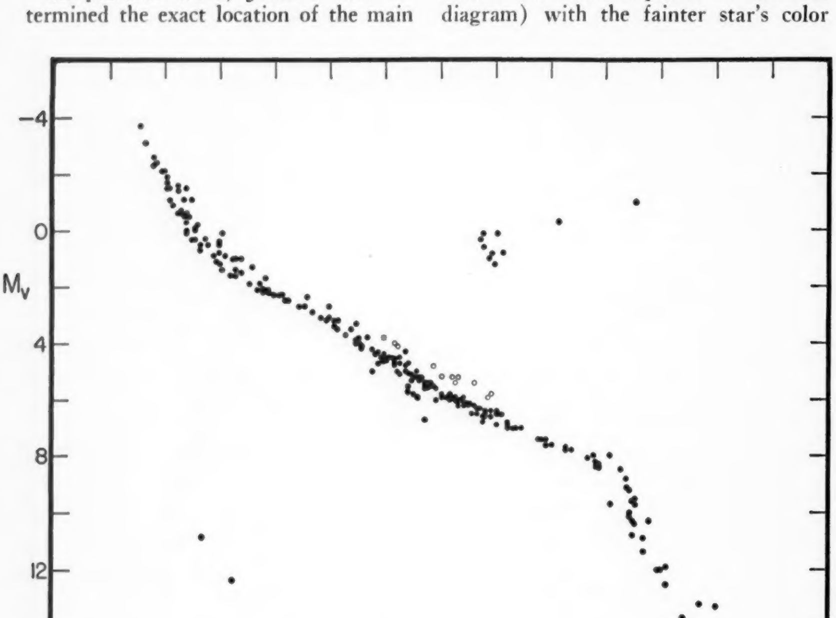
The Internal Constitution of Some Stars

By Otto Struve, *Leuschner Observatory, University of California*

ONE of the most interesting results of recent astronomical exploration was announced by Harold L. Johnson in the May, 1953, issue of the *Astrophysical Journal.* With the help of a photoelectric photometer he measured the visual magnitudes and the color indices of 40 visual double stars selected from R. G. Aitken's catalogue. All of these pairs are believed to be binary systems. For every pair, the two components were separated sufficiently so that each star could be placed in turn upon the diaphragm of the photometer without disturbance from the light of the other component. Since the distances of these stars from us are not accurately known, the absolute visual magnitudes cannot be directly inferred from the measured apparent magnitudes. Nevertheless, the difference between the absolute magnitudes of the two components of each pair is, of course, identical with the difference in apparent magnitude.

In previous work, Johnson had determined the exact location of the main sequence in the Hertzsprung-Russell diagram. His final curve, based upon several galactic clusters and selected nearby single stars whose trigonometric parallaxes were accurately known, appears in the same issue of the *Astrophysical Journal.* It is one of the diagrams reproduced here. The ordinates are visual absolute magnitudes, and the abscissae are color indices, defined as the difference in apparent magnitude for blue and visual light. Nearly all the dots fall upon a narrow band which may be regarded as the best representation of the main sequence known to us at the present time. The only exceptions are a few giants above the main sequence, and five white dwarfs below it.

If it is now assumed that the fainter component of each of the 40 double stars is a member of the main sequence, then its position in the second diagram can be exactly defined by the intersection of the continuous line (which represents the main sequence of the first diagram) with the fainter star's color index, $B - V$. These points are not actually marked in Johnson's diagram. The black dots are the corresponding locations of the brighter components of the 40 pairs, which were located by means of the color index, $B - V$, measured for each brighter star, and by the observed difference in visual magnitude.



The Hertzsprung-Russell diagram constructed by Johnson and Morgan for stars with very accurately known distances. Ordinates are visual absolute magnitude, abscissae are color index. Nearly all the stars plotted belong to the main sequence, but a few giants and white dwarfs are included. The open circles represent Praesepe stars that may be unresolved binaries. Note the narrowness of the main sequence, in contrast to its appearance in earlier diagrams from less accurate data. From the "Astrophysical Journal."

The resulting arrangement of dots in the second diagram indicates a surprisingly large scatter. We are not concerned here with those stars in the upper right corner, which are obviously giants. We are interested in finding that nearly half of the dots fall considerably above the main sequence, sometimes by as much as one magnitude or more.

Johnson states that the assumption that the fainter components belong to the main sequence need not necessarily be true. In making this assumption, he was guided primarily by G. P. Kuiper's earlier conclusion that stars below the main sequence, which we might describe as subdwarfs, are very scarce in Baade's Population I. Of course, the double stars which Johnson has measured are probably all Population I objects. The important thing is that the dispersion of the components of visual double stars is very much greater than might be anticipated from the small scatter of the main sequence as found from galactic clusters and single nearby stars.

Astronomers will undoubtedly wish to repeat Johnson's observations to verify the results. It is to be assumed that he has investigated all possible sources of instrumental error, and the errors arising from the scattered light of the nearby companions. Until confirmation is available, we accept the work with reservation, and shall attempt to formulate an interpretation in terms of the internal constitution of the stars.

Johnson's conclusions, if accepted, must have an evolutionary significance. It is certainly surprising that we cannot, apparently, regard the visual double stars as being closely related to the galactic clusters with respect to their origin and evolution.

In order to explain the high dispersion of the double stars, we are tempted to think first of a nonnuclear process of evolution that will proceed at different rates in the two components. If this were the case, the brighter, and therefore more massive, components of the pairs might evolve more slowly than the fainter and less massive companions. Hence, if the difference is really of an evolutionary character, we should expect the brighter components to belong to the main se-

quence, while the fainter components might then be explained in terms of more rapid evolutionary development.

However, it is also possible that when a double star is formed the processes of condensation in the original cloudlike medium may favor different atomic abundances in the two stars. Such a difference would probably depend upon the distance between the two components, and might be of importance in very close pairs such as those we observe as spectroscopic and eclipsing binaries. Among these very close pairs, similar large departures from the main sequence have been recorded. For example, the spectrographic observations at the McDonald Observatory of Algol-type binaries have shown conclusively that the faint companions in these systems are stars of relatively small mass but of excessive luminosity. They often violate the mass-luminosity relation by factors of the order of 100, or even more, in intrinsic brightness.

There is also a strong indication that the spectral types of these stars may be earlier than would be consistent with their masses. For example, an ordinary main-sequence star of one third the mass of the sun has a spectral type of about *M*5, yet the subgiant companion of the binary XZ Sagittarii has a *G* spectrum. We are, therefore, justified in concluding that these subgiants are not only very much too luminous for their masses, but they also possess spectral types which indicate effective temperatures higher than would be consistent with their small masses.

The resulting departures from the mass-luminosity relation and from the main sequence in the Hertzsprung-Russell diagram are not the same as the departures noted by Johnson, but they, too, constitute another interesting evolutionary problem.

In order to solve this problem we must make an excursion into the field of stellar structure.* To explore the interior constitution of stars other than the sun, we shall use three fundamental laws of physics.

1. The general law of perfect gases states that when the pressure is increased, while the volume of the gas is held constant, the temperature increases in direct proportion. When the temperature is held constant while the pressure is increased, the volume decreases. Elementary textbooks accordingly tell us that the pressure is proportional to the temperature and inversely proportional to the volume of the gas. But for our purpose it is useful to remember that the volume is equal to the mass of the gas divided by the density. Hence we shall assume that the pressure (p) at any point inside a gaseous star is proportional to the density (ρ) and the temperature (T), and inversely proportional to the atomic (or molecular) mass (μ) of the gas particles:

$$p \sim \frac{\rho}{\mu} T.$$

2. The very intense light and heat inside a star is all produced by nuclear reactions near its center. This radiation is trying to escape to the outside, but is restrained by the opacity of the gases, which act just as a sieve acts upon a stream of water. The radiation exerts pressure upon the semiopaque gases that can be measured in the laboratory. This pressure turns out to be proportional to the fourth power of the temperature of the radiating material. The resistance of the gases to this outward pressure causes them to expand a little, thus adjusting the star's radius until the pressure of radiation is just balanced by the resistance of the gas. It is as though our sieve were made of a rubber membrane. As the water presses upon the membrane it expands; the holes also expand and more water can flow through. Finally, the resistance of the membrane prevents further expansion, and from then on a uniform flow of water passes through the sieve.

The resistance of the gases to the pressure of radiation is called the absorption coefficient (K). It turns out to be, for a one-centimeter thickness of gas, proportional to the square of the density of the gas and inversely proportional to the 7/2 power of the temperature:

$$K \sim \rho^2/T^{7/2}.$$

3. We require some knowledge of the process that creates the radiation inside a star. This information comes from the theory of nuclear fusion of hydrogen into helium. It follows from this theory that the amount of energy produced by one gram of gas (ε) in the form of heat and light is proportional to the product of the density and the 18th power of the temperature:

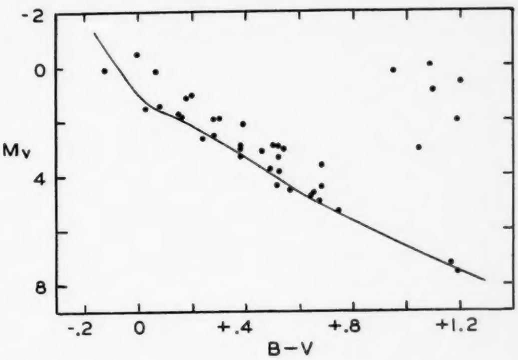
$$\varepsilon \sim \rho T^{18}.$$

Let us now consider two stars: the sun (for which we know the internal distribution of density and temperature, and also, from observation, the total output of heat and light; this total output is the luminosity, 4×10^{33} ergs per second); and a star of spectral type *B* having a mass 10 times that of the sun.

Let us see what we can infer about the luminosity and surface temperature of this *B* star. Our method will be to apply the three physical laws to the sun, and then see what changes result when the sun is converted to a star of 10 times its present mass. We shall do this in a theoretical manner, and at the end shall compare our results with observations.

If we had enough patience, we could start with any assumed value of the radius for the *B* star. For example, we could make it equal to that of the sun. However we would soon find that this assumption would lead to contradictions with one or the other of the three physical laws. By trial and error we would conclude that the only possible radius of the *B* star is 5.1 times the radius of the sun. The reader who wishes to convince himself that any other value is impossible may assume any radius he wishes and carry out the rest of our calculations. At the end he will see why only 5.1 gives a satisfactory result. We shall here take on faith the results of similar calculations by others and proceed with a mass of 10 and a radius of 5.1.

The mean density of the larger star is obtained by dividing its mass by the volume, which gives 0.075 times the density of the sun. Since the mean density of the sun is 1.4 grams per cubic centimeter, that of the *B* star is 0.1 gram per cubic centimeter. Does this density ratio apply only to the mean, or to any corresponding two points inside the two stars? If the latter, then we say that the sun and the *B* star are "built on the same model" or that they are ***homologous***. Eddington and others



The Hertzsprung-Russell diagram of the brighter members of 40 double stars, from Johnson's observations. The ordinates are visual absolute magnitudes, the abscissae, color indices. The curve represents the main sequence, transferred from the previous diagram, and the scale is the same. From the "Astrophysical Journal."

*We shall follow here H. N. Russell's very simple line of reasoning, first employed in Russell, Dugan and Stewart, *Astronomy*, Vol. 2. A more modern and exceedingly fascinating account of this problem is contained in W. H. McCrea's book, ***Physics of the Sun and Stars***, Hutchinson's University Library, London, 1950.

have justified this assumption, and we adopt it here because it seems plausible for stars of the main sequence.

If, then, the densities in the B star are 0.075 times the corresponding densities in the sun, we can next compute the corresponding pressures. The pressure is equal to the weight of material located above any given point, and is given by the force of attraction of the star on this overlying matter. Consider any region of the B star; its mass is 10 times greater than that of the corresponding region in the sun. But the mass of the whole B star is also 10 times greater than the sun's, while the distances in the B star are all enlarged 5.1 times. Therefore the force of gravity is

$$10 \times 10/5.1 \times 5.1$$

times that in the sun. But in the B star the weight presses upon an area which is itself 5.1×5.1 larger than it would be in the sun. Accordingly, the pressure at any point in the B star is

$$10 \times 10/5.1 \times 5.1 \times 5.1 \times 5.1$$

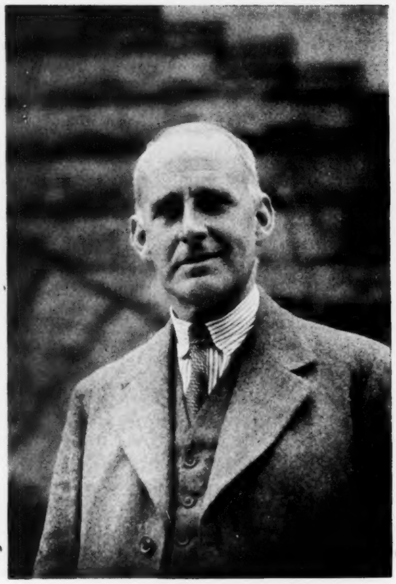
$= 0.15$ times the pressure at the corresponding point in the sun.

We are now ready to apply the first physical law and compute the relative temperatures. We assume that both sun and star have the same chemical composition; if they are made of hydrogen, the atomic mass will be ½. Because the hydrogen atoms are all ionized, the average weight of a particle is equal to the mass of a proton plus the mass of an electron, divided by two.

Then the temperatures within the B star are proportional to the pressures and inversely proportional to the densities, $0.15/0.075 = 2.0$ times greater than in the sun. For example, if the central temperature of the sun is 20 million degrees, a B star with the same chemical composition but with 10 times the mass of the sun would have a central temperature of 40 million degrees.

Next we compute the flow of energy through the star. Take again the analogy of a sieve. If there is water pressing on both sides of the membrane, the flow will be proportional to the difference of the pressures on the two sides. The flow will also be inversely proportional to the resistance of the membrane, or in the case of the star to its absorption coefficient.

A layer one centimeter thick in the sun is expanded in the B star to a thickness of 5.1 centimeters. Since radiation pressure varies as the fourth power of the temperature, in the star this will be $T^4 = 2^4 = 16$ times greater than in the sun. Then the *difference* of the pressures at the inside and outside of the one-centimeter layer is $16/5.1$, about three times greater in the B star than in the sun. Furthermore, according to our second physical law, the absorption coefficient per centimeter is $(0.075)^2/2^{7/2} = 0.0005$ times the sun's.



A. S. Eddington, on whose investigations present-day knowledge of stellar interiors is largely based.

Now we are ready to compute the flow of energy through our one-centimeter layer. It is proportional to the difference of pressures and inversely proportional to the coefficient of absorption. This is easily calculated: $3/0.0005 = 6{,}000$ times that for the sun.

It is rather interesting to realize that without as yet knowing anything about the generation of the B star's energy, we can find that the outward flow of energy, per centimeter, must be 6,000 times greater than in the sun.

The flow measures the amount of radiation escaping per square centimeter. But the B star's surface area is $5.1 \times 5.1 = 26$ times the sun's. Hence, the total energy of the B star, or its luminosity, is $26 \times 6{,}000$ or about 150,000 times that of the sun. This is about 13 magnitudes more luminous than the sun. Since the latter has a bolometric absolute magnitude of about $+5$, the B star's bolometric absolute magnitude would be about -8, and the corresponding visual absolute magnitude -7. From observations of such B stars as Eta Orionis and Spica we actually obtain -5. Our calculation has made the B star about two magnitudes too bright.

The discrepancy is not large when we consider the enormous ratio in luminosity of 150,000 to 1. It must be due to inexactness of one of our basic assumptions, perhaps that of uniformity in chemical composition.

But we must still justify our other assumption, that the radius of the B star is 5.1 times that of the sun. To do so we make use of our third physical law, that of the energy generation, which, per unit mass, is proportional to the density and the 18th power of the temperature. For the entire mass it will be 10 times greater. Hence the total energy generation of the B star exceeds that of the sun by a factor of $10 \times 0.075 \times 2^{18}$, or about 200,000. But the total energy generation is the same as the luminosity. Thus, we obtain nearly the same luminosity in this manner as we had derived from the flow of heat and light through a one-centimeter layer. No such agreement would have been reached had we used a different radius for the B star.

The fact that the luminosity is approximately 10^5 times the sun's gives us the famous mass-luminosity relation. Had we taken a star of spectral type F, with a mass twice that of the sun, the luminosity would have been 2^5 times that of the sun. We say that the exponent of the theoretical mass-luminosity relation is 5. The exponent actually observed is slightly smaller — about 4.

There is also a mass-radius relation. We used it implicitly when we adopted a radius of 5.1 for our B-type star. This relation is the theoretical counterpart of the observational Hertzsprung-Russell diagram.

We are especially interested in how our results would be modified by assuming a different chemical composition. Consider an old star (or one of unusual initial composition) consisting mostly of helium. For hydrogen, as we have seen, the average particle mass is ½. For helium, also completely ionized, there will be an alpha particle of mass 4 and two very light electrons. The average weight per particle is thus 4/3. If the sun is mostly hydrogen, and the star mostly helium, their particle weights are roughly in the ratio 1:2. We will suppose that sun and star have equal masses. In this new problem it again appears that the radius cannot be arbitrarily chosen. By reasoning similar to that used previously, we find the radius of the star to be 1.4 that of the sun.

We can again compute density, temperature, flow of energy, and finally luminosity — always allowing for the difference in particle weight, which enters only into the first physical law. While these computations are recommended as a useful exercise, only the final result is stated here. The helium star turns out to have a luminosity 128 times the sun's. It is approximately five magnitudes brighter than the sun, and has a bolometric absolute magnitude of 0, even though its mass is the same as that of the sun.

We could show that the helium star will have a much higher surface temperature than the sun, about 18,000°. The star will thus appear slightly below the upper part of the main sequence: its spectrum will appear to be that of an underluminous helium star. But its mass will be equal to the sun's. Ac-

cordingly the very old stars of solar mass, which have converted their hydrogen into helium, should now appear as hot stars of abnormally small mass. Perhaps VV Orionis, or even better, the *B*-type companion of Antares, is such an object.

The final result is that we should find a large dispersion in the mass-luminosity relation, and a small one in the Hertzsprung-Russell diagram. Observationally, however, the subgiants have rather large dispersions in both. Hence, the simple Eddington model we have used does not answer our purpose.

We have just seen that a star formed with a subnormal amount of hydrogen, but which otherwise obeys the physical laws for main-sequence stars, would be much too luminous for its mass, and also would be shifted in the Hertzsprung-Russell diagram into a position slightly *below* the main sequence and far to the left of its normal location. We have already noted that the very small subgiant companion of XZ Sagittarii, with a mass about 0.2 that of the sun, would normally be expected to have a spectrum of about d*M*, while its observed spectral type is *G*. It is, however, reasonably certain that this companion falls *above* the main sequence and not below it; thus the simple theory which we have used will not fully account for the observations.

Of course, it is possible that relatively small changes in the physical laws might move the subgiant companions from their predicted locations below the main sequence to positions slightly above it. It is not, however, at all clear at this time which assumption would have to be modified. One possibility would be a change in the law of energy generation for stars of very small mass. The formula we have used, in which energy generation is excessively sensitive to temperature, was derived by H. Bethe on the assumption that hydrogen is converted into helium by the carbon cycle. There are reasons to believe that the cooler stars obtain their energy from another process known as the proton-proton reaction. There is a gradual building up, first of heavy hydrogen as a result of fusion of two protons, then the fusion of another proton to produce a nucleus of mass 3. Finally, after still another proton is added, the resulting particle becomes a normal helium nucleus. This process is less sensitive to the temperature; the amount of energy produced by a gram of gas is proportional to the density (as in the carbon cycle) and to the *fourth* power of the temperature. In the carbon cycle the temperature appears to the *18th* power.

We can now go back and repeat all of our calculations with this new law of energy generation, leaving the other two laws unchanged. The result is no change whatever with respect to the location of a hydrogen-deficient star below the main sequence. Altogether, we can probably conclude that this otherwise tempting hypothesis does not account for the observed properties of the subgiant stars.

Another important modification might result if we had used a different form of the absorption coefficient. In our second physical law, we had assumed that throughout the star the absorption per centimeter was proportional to the square of the density and inversely to the 7/2 power of the temperature. In reality the absorption processes are quite complicated and are almost certainly not the same in different stars or in different regions of the same star. However, as yet very little is known about the actual form of the absorption coefficient, and thus it would be premature to make any substantial changes in the formula we used. The extensive calculations made by astrophysicists with various absorption coefficients do not seriously modify our results. But it is probable that when we know more about the absorption of gases at many millions of degrees, we shall be able to explain why the exponent in the mass-luminosity relation is actually about 4, instead of 5. We may then be able to say why the subgiants tend to fall above the main sequence, instead of below it as predicted by our simplified theory.

Returning now to the stars observed by Johnson, it would appear quite unreasonable to believe that the brighter components were hydrogen-deficient from their beginning. Hence we cannot suppose that the same physical process operates in them as in the subgiant secondaries of the eclipsing systems.

If we arbitrarily modify Johnson's diagram to place all the brighter components on the main sequence, many of the fainter components will be below the main sequence. This would be in the required sense, and could be explained formally on the hypothesis that the less massive components of visual binaries are deficient in hydrogen. However, on physical grounds it seems quite improbable that such a deficiency could occur in double stars with separations of several astronomical units, without having also occurred in the much closer eclipsing and spectroscopic binaries. Hence, the physical processes that have produced the dispersion in the components of double stars are quite unknown. Physical theory is now capable of explaining the major features of the mass-luminosity relation and of the Hertzsprung-Russell diagram. It is not adequate to account fully for the details illustrated by the observations of double stars.

Amateur Astronomers

AMATEUR VISITS GREECE

On August 15th, at 11:00 p.m., I left Idlewild Airport bound for Greece, to see my brother for the first time in 44 years. We crossed the Atlantic Ocean at 26,000 feet, and as the sky was clear I decided not to go to sleep. While I was observing with a flashlight and celestial maps in the darkened cabin, the navigator passed by and stopped to see what I was doing. He invited me to meet the rest of the crew and to look over their instruments.

As we flew over Athens one morning later, I was thrilled by an aerial view of the city of many ancient Greek astronomers. I went to the Athens Observatory, where I met B. Kotsakis, who operates their time-service transit instrument. The main telescope is a 16-inch refractor.

Three days later I went by plane 200 miles north into Macedonia, to explore the ruins of the palaces of King Philip and Alexander the Great. One night I set out to do a little observing, for the Greek sky is very good; I saw there more globular clusters and nebulae than I have anywhere else. That night I had the whole town as my spectators, and they were interested in a brief lecture on the stars.

The people of Greece love astronomy. I was welcomed everywhere that I presented my card as a member of the New York Amateur Astronomers Association.

WILLIAM PIERRE
2401 Cortelyou Rd.
Brooklyn 26, N. Y.

THIS MONTH'S MEETINGS

Buffalo, N. Y.: Buffalo Astronomical Association, 7:30 p.m., Museum of Science. Nov. 4, George A. Davis, Jr., "Desert Stars."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. Nov. 6, Dr. G. Van Biesbroeck, Yerkes Observatory, "Eclipse Hunting in the Sudan."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Texas Bank and Trust Co. Nov. 23, A. W. Mount, "The Observing Program of the Astronomical League."

Indianapolis, Ind.: Indiana Astronomical Society, 2:15 p.m., Cropsey Hall. Nov. 1, Dr. James Cuffey, Indiana University, "Link Observatory Report."

Kalamazoo, Mich.: Kalamazoo Amateur Astronomical Association, 8 p.m., Olds Hall, Kalamazoo College. Nov. 14, student open house; panel discussion, questions and answers.

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Nov. 4, Elisabeth Achelis, World Calendar Association, "The World Calendar."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. James B. Saunders, National Bureau of Standards, "Practical Aspects of Telescope Making."

THREE WEEKS OF SYMPOSIA--I

BY BART J. BOK, *Harvard College Observatory*

AMONG the happiest postwar developments in international relations in science are the symposia that have been organized with assistance from UNESCO and the International Council of Scientific Unions. The actual scientific organization of such a symposium, which generally lasts about a week, is placed in the hands of the international scientific union or unions most directly involved. Thus the scientists themselves are responsible for the planning of the program, the arrangements for the meetings, and the preparation of the final printed proceedings. UNESCO provides limited travel grants and publication funds, which are often supplemented through governmental support, for example, by the National Science Foundation in this country.

I had the good fortune this past summer to attend two of these international symposia, one (June 22-27) in Groningen, Holland, the other (July 6-11) in Cambridge, England. The Groningen symposium dealt with problems of the "Co-ordination of Galactic Research," under sponsorship of the International Astronomical Union. The Cambridge symposium was organized jointly by the International Union of Theoretical and Applied Mechanics and the IAU. It was the second conference (the first was held in Paris in 1949) dealing with "Gas Dynamics of the Interstellar Clouds." Symposia have a way of begetting others, and Number 3 on our itinerary was an informal one on radio astronomy (July 13-15), organized and held by the group at Jodrell Bank Experimental Station near Manchester, England. These meetings produced many results of general interest, and I am glad to have the opportunity of recounting them briefly in advance of the official reports. My account will have to be highly selective, for the amount of science one absorbs in the course of three busy symposia is very great.

THE GRONINGEN SYMPOSIUM

It is almost 50 years since J. C. Kapteyn, of Groningen, proposed his famous plan of selected areas. He realized that it was essential that some degree of co-ordination be effected among astronomers interested in the structure of the Milky Way system. For otherwise there was little hope of making the most efficient use of the labor that would have to go into the determination of magnitudes and colors, spectral types, proper motions, and radial velocities for even a small fraction of the many stars within reach. Kapteyn recommended that the principal efforts be concentrated on 206 relatively small areas of the sky, evenly distributed, which have since become known generally as the Kapteyn selected areas.

From the first, the plan received strong support, and many of us have concentrated our efforts upon work in these selected areas. Some of the principal catalogues give basic information only for stars in the selected areas. These observations have, in turn, had great influence in molding our present views about the structure of the Milky Way; the debt that astronomy owes to Kapteyn's plan is generally acknowledged. During the past decade, however, it has become clear that Kapteyn's original plan provides too few centers right in the galactic belt and that some other scheme for the future co-ordination of galactic research should be evolved.

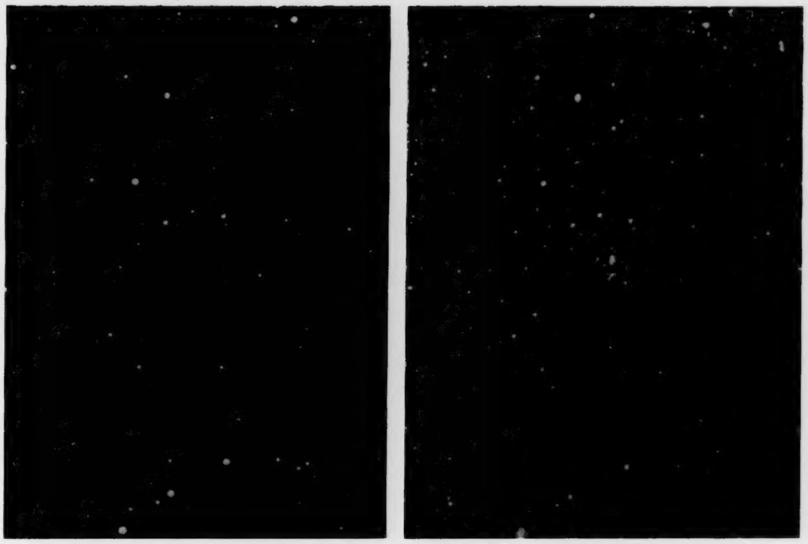
J. C. Kapteyn, pioneer in plans for the co-ordination of galactic research.

To honor Kapteyn's memory, the International Astronomical Union decided to hold this symposium at Groningen. The attendance was limited to about 30 astronomers, from Denmark, France, Germany, Great Britain, Mexico, the Netherlands, the Soviet Union, Sweden, Switzerland, the Union of South Africa, and the United States. The representatives from the United States were W. Baade, W. W. Morgan, J. J. Nassau, J. Schilt, B. Stroemgren, and the author, with Mrs. Bok also attending all the meetings. Milky Way research is one field in which world-wide co-operation is essential, and it was therefore extremely fortunate that the Soviet Union sent a strong delegation, headed by V. A. Ambarzumian and composed of B. V. Kukarkin, T. C. Kulikovsky, O. A. Melnikov, and P. P. Parenago. At Groningen, we all worked together harmoniously in the interest of Milky Way research and we were temporarily able to forget the political problems of the world.

We did not come to Groningen to write a master plan for Milky Way research for the second half of our century, but to assess its current status, to survey new methods of research, and to delineate the framework for more detailed planning in the future.

The symposium opened with reports of new research. Baade spoke about the work of himself and his associates at Mount Wilson and Palomar on spiral structure of nearby galaxies, notably the Andromeda nebula, and stressed the importance of such studies as a preliminary to galactic research. The current evidence seems to indicate that interstellar gas and dust are basic to the formation of spiral arms and that the stars associated with the arms are there only as a consequence of the presence of the gas and dust. In recent years, following Baade's lead, astronomers have paid much attention to the differences between stellar Population I, concentrated in the spiral arms and composed primarily of gas and dust and hot supergiant *O* and *B* stars, and the less spectacular Population II, composed of red giants such as those in globular clusters, the great mass of the common dwarfs and other varieties of stars that inhabit the regions between the arms, the galactic halo, and the region of the galactic center. Baade announced two results that were new to me: The cosmic dust is so heavily concentrated in the inner arms of the Andromeda galaxy that they are practically opaque; and the regular Cepheid variables are highly concentrated in the spiral arms.

Parenago, in his description of current Russian work on stellar motions, stressed that the Soviet astronomers favor a more fluid and continuous system of distinguishing between varieties of galactic stars than is provided by Baade's simple scheme of two populations. There seemed to be pretty general agreement with Parenago that we should at least distinguish among the extreme Population I of the spiral arms, the disk population of the galaxy between the arms, the population represented by the rarefied, outer galactic halo, and that of the central regions of our galaxy.



A new star cluster near the galactic center, photographed in blue light (left) and infrared (right) by M. J. Bester with the 60-inch reflector of the Harvard southern station. Its position is $17^h\ 28^m.0$, $-29°\ 56'$ (1950). In the 30-minute blue negative it is barely visible as an unresolved 19th-magnitude object (invisible in the reproduction), and on the infrared plate it shows as a group of about 50 stars, with a diameter of 50 seconds of arc. No information has previously been published on this cluster, which by means of infrared photography has been independently discovered three times, first by W. Baade with the 48-inch Palomar Schmidt camera, and later at Harvard and by J. Dufay at the Haute Provence Observatory in France.

Parenago's report touched upon a wide range of topics. The Soviet astronomers continue to attach great importance — as do the astronomers of the western world — to the study of what Ambarzumian has called associations of stars. There are two basic varieties of these associations, those of supergiant *O* and *B* stars and those of more dwarfish stars with emission lines, especially found on the fringes of dark nebulae. These have been discussed by Otto Struve in recent articles in this magazine. Closely related to studies of associations is the work on bright emission nebulae, carried on in the Soviet Union principally by G. A. Shajn, V. T. Hase, and V. G. Fessenkov. Finally, Parenago mentioned the great interest in the central region of our galaxy, which is being studied by electronic as well as photographic techniques. The Soviet astronomers place the galactic center a little under 25,000 light-years from the sun, whereas the accepted figure among the astronomers of western Europe and the United States seems to be about 5,000 light-years more.

Spiral structure came in for considerable attention. Almost two years ago, at Yerkes Observatory, Morgan was the first to develop a definite scheme for the spiral structure of the Milky Way. At Groningen, he presented further evidence to strengthen and extend his original outline. He and his associates have derived improved distances for many of the concentrations of stars that mark the spiral arms of the northern Milky Way, one an inner arm in which our sun is located, the other an outer arm at a distance from the center at least 6,000 light-years beyond that of the sun. With A. E. Whitford and A. Code, of the University of Wisconsin, he has also studied the inner spiral arm of the galaxy, which covers a large arc of the southern Milky Way and is about 3,000 light-years closer to the galactic center than the sun. Studies of the inner arm have also been carried on by M. J. Bester, C. M. Wade, and the writer, with photographs made at the Boyden station of Harvard Observatory in South Africa. The presence of two marked concentrations in the inner spiral arm or arms seems to be established.

But as far as spiral structure was concerned, the show was really stolen by J. H. Oort, of Leiden, who reported on his work, with H. C. van de Hulst and C. A. Muller, on the space distribution of neutral hydrogen as revealed by the radio radiation at 21 centimeters. Because of galactic rotation, some of the distant hydrogen clouds have radial velocities very different from the clouds in the sun's vicinity, and they can thus be detected from the radio records. Oort and his associates have succeeded in tracing one spiral arm halfway around the galaxy, almost to the point beyond the center that lies as far from the center as our sun! Perhaps the most striking feature of Oort's principal arm is that it forms an almost ringlike structure instead of a spiral. With the best of modern photographic methods, we hardly penetrate farther than 10,000 light-years from the sun, but the radio methods readily reveal structural features at distances five or more times as large.

Among participants in the Groningen symposium were, left to right: Haro (M), Lindblad (S), Becker (G), Stoy (SA, half-hidden), Baade (A), Heckmann (G), Kourganoff (F), Ramberg (S), Oort (N), Plaut (N), Schalen (S), Blaauw (N), Morgan (A), Spencer Jones (E), Mrs. Nassau (A), Oosterhoff (N), Nassau (A), Mrs. Bok (A), van Rhijn (N), Kulikovsky (R), Kukarkin (R), Ambarzumian (R), Parenago (R), and Melnikov (R). (A, United States; E, England; F, France; G, Germany; M, Mexico; N, Netherlands; R, Russia; S, Sweden; SA, South Africa.) Photograph by Bart J. Bok.

In recent years, astronomers have made more and more use of the red and infrared parts of the spectrum to study the remote sections of the Milky Way. The selective character of interstellar absorption makes it almost impossible to penetrate in certain directions to great distances in normal blue photographic light, but the obscuring clouds are less opaque in the red and infrared. Furthermore, infrared spectra reveal many thousands of hitherto unknown giant and supergiant stars. Nassau reported on infrared spectral classification at the Warner and Swasey Observatory. The late *M*-type supergiants appear to be excellent indicators for remote disk pop-

Informal groups like these supplemented the formal sessions. Left: Melnikov, Ambarzumian, and Fehrenbach; right: Becker, Heckmann, and Bok.

ulation, whereas the *N* stars seem intimately related to the spiral structure itself.

At the Groningen symposium, we paid much attention to instrumentation problems and to techniques. Those present were unanimous in stressing the importance of precision for future work. In spectral classification, the Morgan-Keenan-Kellman system seems to go a long way toward satisfying the need for a dependable two-dimensional method, which yields spectral class and absolute magnitude simultaneously. There was much discussion about how we might go to fainter and fainter apparent magnitudes, and Morgan especially stressed "natural groups," varieties of stars with lines or bands that are readily recognized even on very low-dispersion spectra. In recent years work under Nassau, and at Tonanzintla in Mexico under G. Haro, has proved especially important in this respect.

The photoelectric photometer continues to reign supreme in the measurement of standard magnitudes and colors. Stroemgren reported on recent work by himself and his associates on the adaptation to faint stars of multicolor photometry with narrow-band transmission filters. Tests at the McDonald and Copenhagen observatories, with as many as 26 different filters on a single photometer, have already shown that it is possible to obtain information regarding the spectrum and absolute magnitude for stars far too faint to be reached by average classification techniques. Another field of color photometry that shows great promise is that developed by W. Becker, of Hamburg and Basel, who from three-filter photographic observations has been able to determine distances and absorptions for some of the most remote galactic clusters.

For the future, much emphasis was placed on measuring radial velocities of faint stars en masse with objective-prism techniques. C. Fehrenbach, of Marseilles, is just about to embark upon a wholesale attack on the radial velocities of thousands of faint stars. The importance of extending this type of research to the southern hemisphere was stressed.

The symposium brought out clearly the varieties of objects that are useful for the study of galactic structure. We have already spoken of *O* and *B* stars and of late-type supergiants. Special attention should be paid to the less spectacular *A* stars, also presumably relatively young, which may however have been associated with earlier stages of spirality in our galaxy. Variable stars will undoubtedly continue to play a very important role. RR Lyrae variables, with periods of one day and less, will almost certainly remain our most effective objects for probing the outer halo and the central regions of the system. The regular Cepheid variables continue to be among the most important objects in the sky. They can be observed at great distances, and they should thus reveal much information on the detailed spiral structure of the more remote parts of the galaxy. From their colors we should be able to obtain good information about interstellar absorption at large distances; their radial velocities should continue to bring us more and more new information about galactic rotation. Haro impressed the symposium greatly with his presentation of new results regarding the T Tauri stars and their associations, groups of emission objects observed in great abundance near the borders of dark nebulae. These objects may tell us much that is new about the evolution of more common stars. Finally, the continued careful study of globular and galactic clusters cannot be stressed too much.

Problems of stellar positions and proper motions were given much attention, for in the end our estimates of absolute magnitudes of distant stars depend largely on proper-motion data. O. Heckmann, of Hamburg, spoke about plans for another repetition of the great catalogue of the Astronomische Gesellschaft, which would provide a vast body of new basic information on proper motions of faint stars. P. Couderc, of Paris, asked for and received numerous suggestions for proper-motion work that may now be carried out by repeating the old plates of the *Astrographic Catalogue*, which were taken toward the end of the 19th century.

The principal aim of the Groningen symposium was to provide a guide to future planning. Now will come the preparation of specific programs and the selection of regions of special interest. A small committee was set up to prepare recommendations. With Oort as chairman, this committee has among its members astronomers from the Netherlands, the Soviet Union, Sweden, and the United States.

AMERICAN ASTRONOMERS REPORT

(Continued from page 6)

data published in 1950 by Richardson and Schwarzschild from a high-quality spectrogram exhibiting small Doppler velocities in the solar granules. They also made microdensitometer tracings of several white-light solar photographs taken by W. A. Miller at the RCA Laboratories, Rocky Point, N.Y., and found a brightness structure with a mean spacing of 15,000 kilometers. This value matches the spacing from the turbulence spectrum previously calculated by Frenkiel and Schwarzschild using the spectrogram mentioned above.

Solar Prominence Model

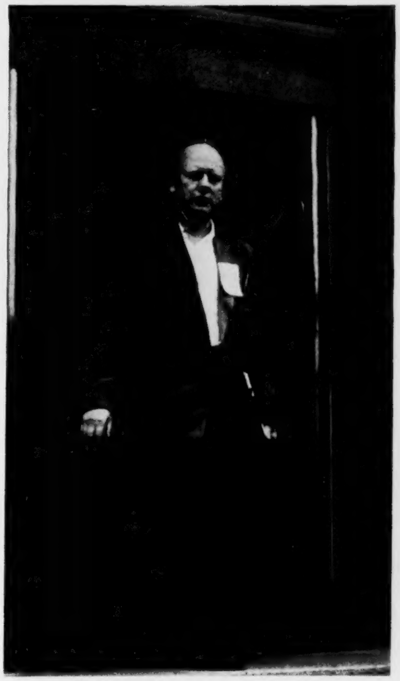
Motion pictures of solar prominences have shown a wealth of puzzling phenomena, such as the prevalent rainlike downward motion of luminous matter in the solar atmosphere, the fine filamentary structure of prominences, and the comparative slowness of the motions of the gases in their curved trajectories. It has frequently been noted that such behavior strongly suggests the presence of electromagnetic fields. This possibility has now been examined quantitatively by Drs. D. Menzel, M. Krook, and R. N. Thomas, of Harvard Observatory.

Their calculations are based upon a simplified model, in which a prominence filament is treated as a flexible wire that falls through a magnetic field. This induces electric currents which interact with each other and with the field. Inductance, rather than resistance, limits the rate of current buildup, because of the low value of the latter. It is found that in prominences electromagnetic forces can largely annul the sun's gravitational force, acting to expand the current loop and to diminish the diameter of each filament. This "pinch" effect eventually cuts off the current and limits its flow.

It further turns out that the total electromagnetic energy of a prominence, on this model, is about the same as that liberated in a solar flare.

Convention at Washington

By C. H. Holton
Atlanta Astronomy Club



G. R. Wright, National Capital Astronomers, and past president of the Astronomical League, was chairman of the Washington convention committee.

TWO auspicious omens were noted on the eve of the general convention of the Astronomical League. A display of the aurora borealis became visible from Washington, D. C., on September 3rd, and on the same day newspapers reported that another crater with a possibly meteoritic origin had been found in northern Canada. The alert program committee deftly landed the crater's first explorer on the podium during the convention's opening session to describe the newly found depression.

Activities during the weekend of September 4-7 centered at the Carnegie Institution. In two spacious halls outside the meeting room there were varied exhibits, including telescopes, optical elements, photographic equipment, planetariums, meteorite sections, books, charts, and society publications. In the auditorium the softly lighted sun and the surrounding transparencies of lunar phases inlaid in the ceiling (see the picture on page 183, May issue) shed an astronomical glow over the 228 persons who registered and attended the general sessions.

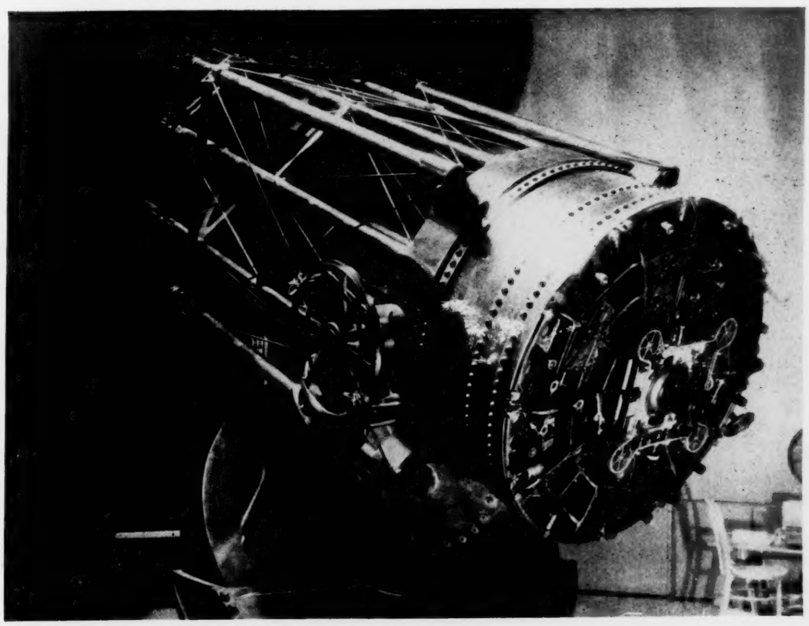
Friday's highlight was the evening tour of the U. S. Naval Observatory, where several staff astronomers greeted us. A clear sky co-operated in such displays as the Ring nebula through the 26-inch refractor and the globular cluster in Hercules through the 40-inch reflector. In the administration building the library, instruments of the time service, and a demonstration of equipment used in the moon survey program were the chief attractions. This program, under C. B. Watts, will determine irregularities around the edge of the lunar disk for all librations. The 6-inch transit circle and the 15-inch photographic refractor were exhibited and their operations explained to successive waves of visitors. Members of the National Capital Astronomers, our host society, pointed out the small building on the observatory grounds that houses their refracting telescope.

The surprise talk Saturday morning was by Dr. V. Ben Meen, director of the Royal Ontario Museum of Geology and Mineralogy, and it was made possible through the courtesy of the National Geographic Society, sponsor of Dr. Meen's detailed exploration of Chubb crater and of his recent flight to the new crater. As described in the news note on page 319 last month, he was able to spend only a short time at the rim of the new crater.

Reports of officers and section chairmen of the league indicated growth of the organization and progress in its activities during the past year. Grace C. Scholz, executive secretary, stated that there were 72 member organizations and 22 members-at-large, with over 4,000 individual members. The number of societies had increased by 10 during the past year, including four junior groups. An invitation for the league to become affiliated with the American Association for the Advancement of Science was accepted by the council.

During the convention roll call representatives of 33 organizations were seen to rise, some of them from distant places in Florida, Illinois, Missouri, Texas, and Wisconsin. To save time, the reading of society reports was omitted; these will be published, however, in the *Proceedings* of the convention.

In all, 31 papers and addresses were given, while two others were read by title and earmarked for inclusion in the *Proceedings*. Of these, nine were read during the observing session on Saturday afternoon. The junior session on Sunday contained seven papers by junior members from Ft. Worth, Norfolk, Schenectady, and Washington. Also on Sunday there were five addresses on radio astronomy and other selected subjects. The instruments session on Monday in-



The 40-inch reflector of the U. S. Naval Observatory. Although shown here with an eyepiece for visual use, the telescope is devoted primarily to photoelectric photometry and measuring the polarization of starlight.

volved five talks, while the final "Operation Eclipse" session had four speakers.

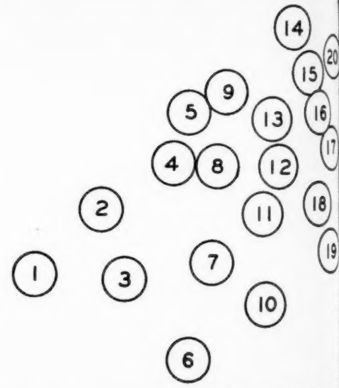
The program was diversified, and amateurs and professionals alike shared with the audience the fruits of their experiences and their thinking. John J. Ruiz, of the AAVSO, contributed two papers on amateur photoelectric photometry. Donald S. Kimball, Yale University Observatory, showed how observations of the aurora are being reported and interpreted. The Rev. F. J. Heyden, S. J., director of Georgetown College Observatory, mentioned several projects for groups of amateurs. In addition, he indicated that there are still openings for qualified helpers in some of the observing parties he is to direct in studying the solar eclipse next June.

The use of radio telescopes in observing the sun's activity was described in a paper by Alan H. Shapley, of the Central Radio Propagation Laboratory. Two approaches to a fuller knowledge of our galaxy were discussed: first, radio observations by means of the 21-cm. hydrogen emission line, by Edward F. McClain, of the Naval Research Laboratory; and second, by means of photoelectric photometry, by A. H. Mikesell, Naval Observatory. Amateur telescope making was likewise doubly featured: by Rolland R. LaPelle, president of the league, who showed pictures of telescopes built by West Coast amateurs whom he visited recently; and by Leo N. Schoenig, of the Amateur Astronomers Association of Pittsburgh, who demonstrated improved devices for mounting the optical parts of reflectors. He advocated particularly the use of interlocking circles for the support of the secondary mirror or prism.

Dr. John A. O'Keefe, Army Map Service, discussed the practical value of a small satellite, one weighing only a few pounds. A "minimum" satellite, proposed by Dr. I. M. Levitt, of the Fels Planetarium, would cost only a fraction of the billions of dollars estimated for large, manned vehicles such as have gained wide publicity in recent years, and would aid in solving many problems in astronomy and geodesy.

This small moon might be a balloon of aluminum, perhaps eight feet in diameter, which would retain its size even though punctured by meteorites. At night or in full daylight, it could not be seen, but it should shine well by reflected sunlight against the darkened skies of dawn and twilight. Or if it were constructed of corner-cube reflectors, which reflect light back to the source, illumination of the satellite at night by standard searchlights does not appear impossible.

Assuming that such an object could be put into a two-hour orbit about a thousand miles high, Dr. O'Keefe finds that it would give us the same observing opportunities the moon does now, but without some of the moon's disadvantages. It would be starlike, easy to locate accurately. Gravitational disturbances by the sun would be practically eliminated. There would be no limb irregularity. It would provide an accurate means of determining both the mean force of gravity of the earth, and the earth's radius. Improved determinations of the shape of the earth would result, and possible flattening in the equatorial plane might even be found.

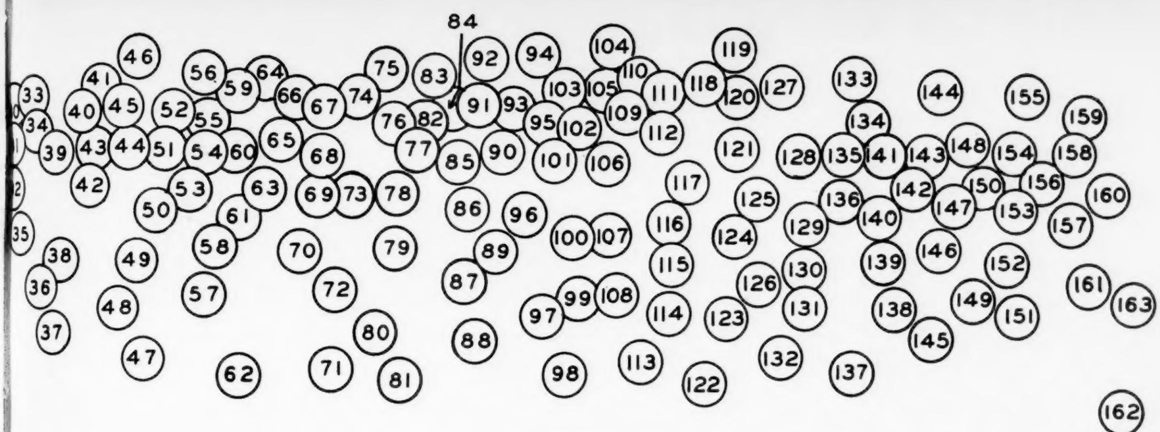


The general con

The 1952 eclipse expedition of the Naval Research Laboratory to Khartoum was dramatically shown in a color movie, portraying completely the total phase of the eclipse and showing the preparations and the instruments used. Fred T. Haddock, of NRL, commented on the film during its projection.

A rainstorm on Saturday prevented an outdoor buffet supper and observing at Georgetown University. The trip was made, however, and the supper was enjoyed by a good-natured crowd in the college dining hall. The annual Astronomical League award was presented by President LaPelle to Charles A. Federer, Jr., for his work in organizing the activities of amateur astronomers. Then Father Heyden announced open

A high point of the convention was the visit to the Naval Research Laboratory, where this 50-foot radio telescope was inspected. The incoming radiation is focused on a wave trap at the end of the central support (held by guy wires). This trap is reached by raising the scaffold resting on the roof to the right of the group of amateurs. The Potomac River is in the background.



e Astronomical League at Washington, D. C., September 4-7, 1953. Photo by Ankers Photographers.

KEY TO PHOTOGRAPH

1, J. Moore, Mo; 2, C. Billings, Pa; 3, J. Stith, Va; 4, M. Lewis, NJ; 5, F. Mason, Ill; 6, F. Dachille, Jr., Fla; 7, Dr. E. Boyd, NC; 8, C. S. Johnson, Mich; 9, Miss G. Carr, NY; 10, Mrs. Z. V. Conyers, NC; 11, G. Neaves, NC; 12, Miss I. Warthen, Md; 13, Miss C. Culp, Mich; 14, J. Golden, NY; 15, Miss E. Vadala, Pa; 16, C. Cuevas, NY; 17, W. Hyde, Va; 18, D. Neaves, NC; 19, Miss G. Scholz, Md; 20, J. Rosenquist, NY.

21, Mrs. J. Ralph, Ky; 22, M. Marshall, Va; 23, K. Weitzenhoffer, NY; 24, Mrs. R. Dellar, Va; 25, R. Dellar, Va; 26, M. Schiff, DC; 27, H. Williams, Pa; 28, E. Marshall, Va; 29, Mrs. R. LaPelle, Pa; 30, A. Krauss, Ky; 31, J. Ralph, Ky; 32, Dr. J. Gant, DC; 33, E. Gilmore, Pa; 34, W. Reid, NY; 35, N. Anderson, Va; 36, H. Sehested, Tex; 37, R. LaPelle, Pa; 38, Dr. H. Sehested, Tex; 39, A. Mount, Tex; 40, V. Griffin, Jr., Va.

41, E. Klein, Pa; 42, J. Anderer, Ill; 43, Mrs. J. Kyle, Fla; 44, W. Cleaver, Conn; 45, O. Ranck, Pa; 46, H. Ross, NY; 47, Mrs. M. Chircop, Mich; 48, Mrs. G. Rademacher, Conn; 49, R. Fink, Wis; 50, R. Soucy, Va; 51, Miss F. Rosenblatt, NY; 52, J. Reed, Mo; 53, R. Misner, DC; 54, F. Burnham, Conn; 55, J. Ruiz, NY; 56, R. Sanderlin, Va; 57, W. Wilson, Pa; 58, J. Neff, Wis; 59, E. Bailey, Pa; 60, L. Schoenig, Pa.

61, Miss J. Burden, NY; 62, Mrs. I. Wilson, Pa; 63, J. Kaler, NY; 64, B. Adelman, DC; 65, E. Henning, Va; 66, C. Holton, Ga; 67, A. Vogeler, NY; 68, C. Jenkins, Va; 69, E. Greenwood, Ont; 70, W. Calder, Ga; 71, D. Woods, NY; 72, E. Cramer, Tex; 73, Mrs. C. Zemlock, Wis; 74, R. Dodd, Wis; 75, W. Ferguson, Va; 76, R. Buckstaff, Wis; 77, J. Lubor, Md; 78, D. O'Brien, Wis; 79, C. LeRoy, Pa; 80, Mrs. J. Woods, NY.

81, E. Seymour, Jr., Va; 82, F. Dachille, Fla; 83, C. Little, Jr., DC; 84, Mrs. F. Dachille, Fla; 85, Miss T. Cressy, DC; 86, W. O'Brien, Wis; 87, C. Johnson, NY; 88, C. Strull, Ky; 89, P. Stevens, NY; 90, J. Buhler, Tenn; 91, L. Scott, Md; 92, Dr. M. Robinson, NY; 93, Mrs. E. Seymour, Va; 94, Mrs. M. Robinson, NY; 95, B. Ragland, Va; 96, W. Stone, Conn; 97, Mrs. C. Gamble, Ill; 98, Mrs. C. Strull, Ky; 99, Miss I. Bootier, NY; 100, M. Groff, NY.

101, T. Hartzog, Tenn; 102, J. Forkner, Pa; 103, R. Smith, Md; 104, C. Cook, Mass; 105, L. Johnson, Md; 106, J. Burns, Pa; 107, Miss I. Harden, Va; 108, C. Gamble, Ill; 109, J. Fierstein, Pa; 110, unidentified; 111, T. Ogburn, Va; 112, P. Klatt, Pa; 113, James Boland, Ga; 114, Mrs. R. Wicke, Va; 115, H. Becker, Pa; 116, Miss E. Fazekas, Md; 117, L. Maggitti, Pa; 118, M. Rosenthal, Pa; 119, D. Kimball, Conn; 120, E. Seymour, Va.

121, H. Bondy, NY; 122, Miss F. Dachille, Fla; 123, E. Causey, Va; 124, J. King, Tex; 125, H. Chandler, NM; 126, R. Wicke, Va; 127, D. Law, Va; 128, W. Isherwood, Md; 129, Miss K. Gross, Tex; 130, Mrs. F. Boland, Ga; 131, Miss S. Furnald, Conn; 132, Miss L. Budd, Conn; 133, E. Oravec, NY; 134, H. Luft, NY; 135, A. Hustead, Va; 136, F. Boland, Ga; 137, Mrs. H. Velardi, Conn; 138, F. Velardi, Conn; 139, Mrs. H. Federer, Mass; 140, John Boland, Ga.

141, H. Walls, Md; 142, A. White, Va; 143, P. Davis, DC; 144, Dr. H. Downey, Wis; 145, Mrs. O. Carney, Conn; 146, Miss B. Federer, Mass; 147, C. Federer, Jr., Mass; 148, R. Wright, Mass; 149, Miss F. Welter, Conn; 150, Mrs. O. Grunow, Mich; 151, D. Carney, Conn; 152, Miss E. Isherwood, Md; 153, C. Federer, III, Mass; 154, Mrs. J. Wright, Md; 155, J. Lund, Md; 156, Mrs. R. Cole, Pa; 157, Mrs. B. LuCaric, Pa; 158, Miss M. Sterns, DC; 159, S. Lyons, DC; 160, T. LuCaric, Pa.

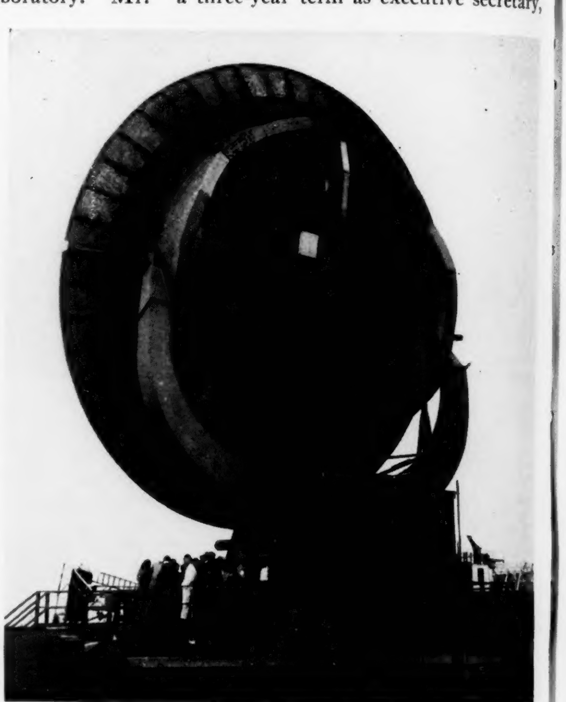
161, Miss R. Heisey, DC; 162, Miss J. Dachille, Fla; 163, R. Wright, Md.

house at the observatory. Those who braved the heavy rain and the slippery ascent to the high point where the building is located were repaid by a chance to see the venerable refractor and a large spectroscope which is used in studying the sun.

Continuing rain on Sunday morning failed to deter the group that visited the Naval Research Laboratory. Mr. Haddock described the operation of the 50-foot paraboloidal "dish" that gathers in radio noise from the sun. In a penthouse on a second roof the recording apparatus and several smaller receivers were inspected.

At the business session of the convention, President LaPelle stated that the manual for observers is now being edited by Don Zahner, of St. Louis; Sky Publishing Corporation will consider problems of publication when the editing is completed. The Astronomical League *Bulletin* will again be in the capable hands of the New Haven group, and Mr. Kimball, Box 2023 Yale Station, New Haven, Conn., will continue to receive items for that publication. Mrs. Frank Velardi, 108 Orange St., New Haven, will handle annual bulk subscriptions at 25 cents for the five issues. However, any individual who wishes to receive each number of the *Bulletin* directly by mail may send 50 cents and five self-addressed long envelopes to Mrs. Velardi. The convention *Proceedings,* edited by this writer, will be published this year by Russell C. Maag and his Missouri assistants. Anyone who did not order a copy in Washington may purchase it by sending $1.50 to Mr. Maag at 816½ S. Massachusetts Ave., Sedalia, Mo.

League officers for 1953-54 are Mr. LaPelle, Meadville, Pa., president for a second term; James H. Karle, Portland, Ore., vice-president (last year's secretary); Mr. Maag, secretary (last year's treasurer); Mrs. Ralph N. Buckstaff, Oshkosh, Wis., treasurer; and for a three-year term as executive secretary, Mrs. Olive Grunow, Detroit, Mich.



This view of the rear of the large radio receiver at the Naval Research Laboratory shows the altazimuth mounting of the apparatus. In a nearby building a robot equatorial mounting can be set in equatorial coordinates; this robot then transmits the correct changes of altitude and azimuth to the controls of the receiver.

Roy L. Dodd, of the Milwaukee Astronomical Society, sketched plans for the 1954 convention, which is to be held at Madison, Wis., over the 4th of July weekend. Not only are living accommodations arranged and announced, but reservations are already being taken for a bus tour leaving Milwaukee in time to reach the Keweenaw peninsula in upper Michigan for the eclipse of the sun on June 30th, continuing afterward to Madison in time for the convention. Further information can be had from Mr. Dodd, whose address is 7918 Milwaukee Ave., Milwaukee 13, Wis. The total cost of the tour bus ride will be $20 per person or less. Reservations will be accepted for 74 league members and their families who deposit five dollars per person. A few additional names will form a waiting list. Cancellations can be made before June 15th.

On invitation of the Northwest region of the Astronomical League, the 1955 general convention will be in Seattle, Wash.

Those who shared in this gathering will remember ideas presented, and above all they will cherish renewed acquaintances and newly formed friendships with other league members.

☆ ☆ SKY AND TEACHER ☆ ☆

Conducted by STANLEY P. WYATT, JR., *for the Teachers' Committee of the American Astronomical Society*

A New Column

Have you ever told a friend how to locate Polaris, or shown somebody the Orion nebula through a 4-inch refractor, or taught astrophysics in a university? If you have ever pointed out or explained anything astronomical, then you have played the role of a teacher of astronomy. Perhaps your chief activity is public school or college teaching; perhaps not. In any case, this issue of *Sky and Telescope* brings into being a new bi-monthly column for all teachers of astronomy, Sky and Teacher, devoted to a consideration of all phases of astronomical instruction.

Our broad objective is the discussion of topics of interest to "all kinds of teachers of all kinds of students." Sometimes we shall focus attention on useful demonstration apparatus, sometimes on plans for courses in astronomy, sometimes on the place that astronomy has in the grand sweep of all knowledge. Not only will the range be broad, but at times the issues will be controversial.

For instance, although I imagine all of us will agree quite precisely on the apparent place of Alpha Orionis on the celestial sphere today, and most of us that the galaxies are about twice as far away as we thought a couple of years ago, there is by no means any broad area of agreement on just which topics to include and which to omit in teaching astronomy to a class of college freshmen.

Sky and Teacher is sponsored by the teachers' committee of the American Astronomical Society. At present, the members of this committee are Paul Herget, University of Cincinnati; Wasley Krogdahl, Northwestern University; Ruth Northcott, University of Toronto; Marguerite Risley, Randolph-Macon Woman's College; Peter van de Kamp, Swarthmore College; and (chairman) Stanley P. Wyatt, Jr., University of Illinois. The teachers' committee is dedicated to the collection and exchange of information on astronomical teaching at the college level.

Our column, however, has wider aims. It seeks out everybody who ever has said, or indeed would ever like to say, anything about the stars to other people. For our general objective of bettering university teaching of astronomy implies a far broader set of concerns. We should like to excite the interest of people everywhere in atoms, planets, and galaxies; we want to see the young man or woman who has both the deep enthusiasm and the native stuff think hard about an astronomical career; we recognize that there is always room for more effective teaching of the stars in junior and senior high schools, in colleges and universities, among amateur societies, on radio and television.

The subjects, then, that may be discussed in this column will come from areas far broader than those of college teaching alone. We hope that a considerable number of astronomers will be contributing, but articles and suggestions concerning teaching activities will be welcome from amateurs and other readers.

Some Things To Keep in Mind

In this first column I should like to set down in random order a few suggestions on astronomy teaching that would seem to be applicable rather generally at all levels of instruction.

1. *Work with your subject.* Be reflective about and have fun with those topics you teach. Although digestion of a good textbook is rewarding, it is probably not enough. Where possible, know your material more intimately by working with, through, and around it.

2. *Elect a well-defined objective.* You may be teaching people how to read a map of the sky, or how to apply integral calculus to solve a research problem; your course may be a search to discover man's place in the physical and moral universe. Whatever the level, remember your aim and stick with it.

3. *Stay up to date.* Get some of the facts of radio astronomy into your notes; know the new distance scale; keep pace with current ideas on the origin of the solar system. Many in your audience thumb through *Life,* or *Collier's,* or *Time;* the wide-awake ones will have some questions for you.

4. *Don't tell too much.* A painstaking and exhaustive survey of everything in astronomy tends to become instruction by rote; the life and spirit of the subject may never emerge. No one person can be deeply excited about every phase of the field. Perhaps the dynamics of interplanetary travel is fun for you, or perhaps you have a special way with time, or with novae. All right, teach them. But if you cannot stand ecliptic co-ordinates, or if you cannot breathe life into the methods of spectral classification, don't teach them in detail. Those who study astronomy as a liberalizing experience will scarcely be helped if you do; and if there should by any chance be a future professional astronomer in the third row, he can find out for himself. Within the limits imposed by good organization, teach few things well, and especially teach the topics that stir you most.

S. P. W., JR.

BOOKS AND THE SKY

SIR JAMES JEANS

E. A. Milne. Cambridge University Press, New York, 1952. 176 pages. $4.00.

MILNE'S biography of Jeans is a very exceptional book — a critical account of one scientific scholar, written by another. As such it has unusual interest for the research astronomer. Milne brought his subtle and delicate mind to bear on the work that Jeans conceived on a majestic scale and executed with robust vigor.

Completed just before the biographer's death in 1950, this is no popularized treatment of Jeans. Milne had himself been in the thick of the discussions, especially those of stellar structure, and his account of the classical controversies between Jeans and Eddington is more than the narrative of an eyewitness. It is the critical appraisal by a protagonist of a combat that was one of the decisive battles of astronomy. After reading it we ask, not for the first time: "And whose corpse **did** lie stricken on the field?"

The famous controversy was fought out on the floor of the Royal Astronomical Society in London. It attracted so much attention, as Milne records, that several pure mathematicians, notably G. H. Hardy, became members of the society for the purpose of following its course. The criticisms that Jeans leveled at Eddington were far reaching. The former supposed the interiors of the stars to be essentially liquid and to contain elements heavier than those known on earth, in marked contrast to Eddington's insistence on the gaseous nature of stellar interiors. Jeans differed from his opponent, too, in believing that the theory was more complicated, and involved more parameters, than Eddington found it necessary to employ.

One particular criticism, which now seems to have been well founded, was that stellar interiors are not hot enough to produce the observed liberation of energy. Eddington's retort has gone down in history: he asked his critic to "go find a hotter place."

Following the first half of the book, which develops chronologically, the second part contains a technical description of the contributions of Jeans to astronomical research, from the "ultraviolet catastrophe," through the theory of rotating fluid masses, to the internal constitution of stars. If some of his results are obsolete today, they stimulated the researches that replaced them.

The greater part of the book is devoted to Jeans the scholar: student, writer of textbooks, developer of theories of cosmogony. At 50, the author of recondite mathematical books becomes the popularizer of science and the philosophy of nature. And perhaps the most interesting sections relate to Jeans the man. The little prefatory biographical memoir by publisher S. C. Roberts is a revelation to those of us who saw in Jeans a brusque and forbidding figure, for it reveals a convincing glimpse of a man both shy and lonely.

The last chapter in the book, which deals with Jeans' philosophy, will be of interest to all readers, both scientists and laymen. Like almost every popularizer of cosmogony (including Eddington), he gave expression to his own views on the fundamental problems that link science and religion, views that many of his critics, like the present reviewer, consider outside the legitimate orbit of the pure scientist. Man tends, it is said, to make God in his own image, and Jeans was no exception. To him, God was the Supreme Mathematician. It is a noble view, beyond the grasp of the less sophisticated mind, and it cannot fail to elevate, even though it may not edify the reader. The gift of expression, which won Jeans a place in the **Oxford Book of English Prose,** was never more eloquently used. When he wrote of what were to him the eternal verities, his language took on some of the quality of the organ, the musical instrument to which so many of his leisure hours were devoted.

Milne's appraisal of Jeans is one that invites careful perusal. It shows Jeans mirrored in Milne's own personality, with its keen, delicate scientific estheticism. Some of its detail will interest only a few, and many topics are of purely technical concern. But again and again one sees a small facet brightly illuminated in the play of one brilliant mind upon another. Few scientific men have had so discriminating a biographer.

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THE COMETS AND THEIR ORIGIN

R. A. Lyttleton. Cambridge University Press, New York, 1953. 173 pages. $5.00.

THE SCOPE of this book is actually narrower than its title might suggest, for it is largely devoted to an exposition of the author's own views of the origin of comets, and does not present an overall picture of this problem. Lyttleton proposes that comets are formed by an accretion process from interstellar matter. The passage of the sun through an interstellar dust cloud gives rise to a longitudinal streamer of material at a higher density. The streamer becomes segmented, and segments remote from the sun may contract by internal gravitational forces to form comets.

While it is valuable to have a systematic exposition of this theory, there is difficulty in recommending **The Comets and Their Origin** on any other ground. The book omits any mention of the important recent investigations by Oort, van Woerkom, Whipple, and others. When these omissions are compared with the author's lament in his preface of the almost complete neglect of cometary studies in recent years, it would appear that Lyttleton was unaware of much of the important recent work in his chosen field.

This impression is strengthened by the dependence of the first two chapters, which give a general account of comets, upon 19th-century books, and the brief treatment there of modern topics.

The reputation of the Cambridge University Press for the fine appearance of its publications is well maintained by this volume.

J. A.

THE END OF THE WORLD: A SCIENTIFIC INQUIRY

Kenneth Heuer. Rinehart and Co., Inc., New York, 1953. 220 pages. $3.00.

THIS BOOK would seem to be an expanded version of a popular Hayden Planetarium lecture of similar title. Altogether it is a difficult book for the reviewer. The subject matter makes it nearly as general as a horoscope, and the critical reader cannot help but feel that the book does not live up to the second part of its title.

In his first chapter, "Prophets of Doom," Mr. Heuer reviews some of the earlier occasions in history at which the world's end was expected on the basis of Biblical and astrological lore and incomplete astronomical data. We are reminded that, although these events failed to transpire, the forces of nature can and do bring about great destruction, and we are led to believe that the hour is now at hand when man is capable of producing his own end, if not that of the world itself. . . . "A hydrogen bomb may blow up our planet." This preoccupation with the possibility of total atomic annihilation is evident throughout the book, and is brought to its logical conclusion in the sixth chapter, "Atomic War."

We are treated chapter by chapter to accounts of various astronomical means to the end: comet collisions; moon, asteroid and star collisions; the explosion of the sun, and the death of the sun. The reader has more and more the uneasy feeling that he is reading a perhaps not purposeful distortion verging on the science fiction literature so much in vogue these days. It is annoying to read such half-truthful and dramatic touches as in the second chapter, where the destruction of the earth, or its "becoming uninhabitable," is presented as "an event which probably happened and is happening to other worlds."

The author properly compares and condemns Whiston and Velikovsky for wandering far afield from the scientific method in attempting to combine theology and folklore with astronomy, yet he himself can write, "If the earth were immersed in a comet's tail a spark might cause the whole incumbent mass of atmosphere in which we exist to burst at once into a species of intense flame."

Fantasy abounds in Mr. Heuer's treatment. He paraphrases the story of the Deluge by bringing it forward 50 million years, when man and two of each other "desirable" animal escape by atomic rocket to the shores of a "new world." More fantastic are "the possible inhabitants who dwell in the sun . . . flamelike organisms perhaps even excelling man in intelligence." Although the author argues that "terrestrials will likely never know if such incandescent beings have been created," we do not hesitate to disagree.

Later, however, the author deflates all but one of the end of the world possibilities as being exceedingly remote and proceeds to describe the atomic Utopia of the future, in which man enjoys interplanetary freedom. That others share the belief of the Hayden Planetarium staff that astronomers will reach the moon by 1975 and advance quickly to other worlds is attested by the response to a publicity stunt for their space show, in which visitors were invited to make reservations for the first scheduled space journeys. The quotes from their correspondence are revealing. Mr. Heuer draws the odd conclusion from all this that the public is "intellectually and emotionally prepared" for space travel.

In a chapter on the future of the universe, various theories of cosmogony are outlined and the theory of continuous creation is given an entirely new complexion. Few scientists will agree with Mr. Heuer that "life is the purpose of the universe." And the outlook of the book as a whole is but one step removed from the anthropocentric ideas the author seems to deplore.

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NEW BOOKS RECEIVED

THE STABILITY OF ROTATING LIQUID MASSES, *R. A. Lyttleton*, 1953, *Cambridge University Press*. 150 pages. $6.50.

This is a highly technical discussion, entirely mathematical in character, of the shapes assumed by a rotating fluid body which is held together by gravitational forces. The results of this analysis are applied to the formation of satellites and of binary star systems. The main conclusion reached is that, contrary to earlier findings by Jeans, the birth of binary systems by the fission of a rapidly rotating single body is dynamically unlikely.

ASTRONOMISCHER JAHRESBERICHT, Vol. 50, 1953, Astronomische Rechen-Institut, Seminarienhaus, Augustinergasse 15, Heidelberg, Germany. 445 pages. DM 50.

The latest installment of one of the most useful of astronomical reference works, this volume is a complete list by subject of the astronomical literature which appeared in 1950. All important article references are accompanied by a short abstract in German.

RELATIVITY AND REALITY, *E. G. Barter*, 1953, *Philosophical Library*. 131 pages. $4.75.

This work is described by its subtitle as "a re-interpretation of anomalies appearing in the theories of relativity." It deals with the philosophical problems of relativity, rather than with the mathematical or observational aspects of the subject.

NEW GENERAL CATALOGUE OF NEBULAE AND CLUSTERS OF STARS, INDEX CATALOGUE, SECOND INDEX CATALOGUE, *J. L. E. Dreyer*, 1953, *Royal Astronomical Society*, Burlington House, London W1. 378 pages. £3 10s.

These three catalogues of nebulae and clusters originally appeared in the *Memoirs* of the Royal Astronomical Society in 1888, 1895, and 1908, respectively, and have long been out of print. This new edition of the NGC and index catalogues is a reprint, without any change except for consecutive pagination. For 14,575 nebulae and clusters are listed positions, precessions, descriptions, and references. No other compilation as complete as this exists.

THE RISE OF THE NEW PHYSICS, *A. D'Abro*, 1953, *Dover*. 2 vol., 982 pages, 36 portraits. $3.90, paper bound; $7.00, cloth bound.

This is a corrected and enlarged revision of the first edition, which appeared in 1939 under the title *The Decline of Mechanism*. It gives a comprehensive survey of classical physics and atomic theory.

CONQUEST OF THE MOON, *Wernher von Braun, Fred L. Whipple, and Willy Ley*, 1953, *Viking*. 126 pages. $4.50.

The symposium "Man in the Moon" which appeared in *Collier's* magazine has been enlarged fivefold to make this book. It describes in considerable detail the building of a spaceship, a round trip to the moon, and the work of a scientific expedition on the moon.

GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

NOTES ON BASIC OPTICS — IV

D. Simulation of Optical Systems

1. **Two Positive Lenses.** In our last installment, we described how a pair of lenses can form an image. The discussion there was general, but we shall now consider its applications to actual optical instruments. The starting point is Equation 6, repeated here for convenience:

$$\mathrm{EFL} = \frac{f_1 f_2}{f_1 + f_2 - t}. \qquad (6)$$

Letting $t = 0$ gives the limiting case when the two lenses are placed in contact:

$$\frac{1}{\mathrm{EFL}} = \frac{1}{f_1} + \frac{1}{f_2}. \qquad (6a)$$

If now we separate the two lenses by a distance that is less than either f_1 or f_2, they will form an erecting system. When $t = f_1$, the back focal length BFL is **O** (I) (see Equation 5 and Fig. 10 of the September installment), and

$$\mathrm{EFL} = f_1, \qquad (6b)$$

and we have approximately the case of a positive eyepiece.

Increasing t further makes the EFL greater, until, when $t = f_1 + f_2$, the denominators of both (5) and (6) become zero, and EFL and BFL are both infinite. This is the case of a Keplerian or ordinary inverting astronomical telescope, in which one lens serves as the objective and the other as the eyepiece (Fig. 12A). If we increase t still further, our pair of lenses becomes a compound microscope, where the objective is used to image a nearby object in the focal plane of the eyepiece (Fig. 12B).

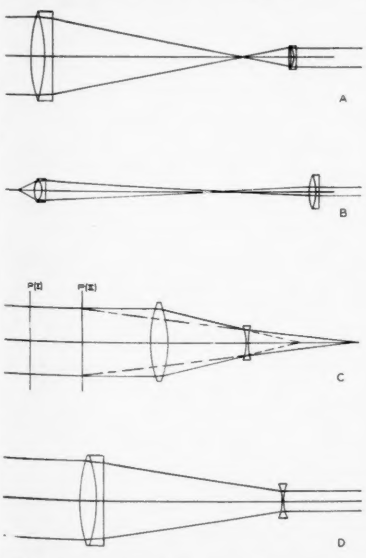

Fig. 12. Two positive lenses separated by the sum of their focal lengths form an inverting telescope, A, and a compound microscope, B, if the spacing exceeds the sum of the focal lengths. If the second lens is negative, a telephoto lens, C, results when the lens separation is less than either focal length. An erecting telescope is formed if this separation is the sum of the focal lengths, as in D.

2. **Positive and Negative Lenses.** A similar examination of the possibilities can be made when one of the lenses is positive and the other negative. The first case, where $t = 0$, corresponds to a doublet objective, and we have Equation 6a again.

If t is increased, but remains less than either f_1 or f_2, we have the telephoto lens (Fig. 12C). The advantages of this lens can be seen from the mathematics. If we write the separation as a fraction of f_1 ($t = Kf_1$), Equation 5 becomes

$$\mathrm{BFL} = \frac{f_2 f_1 (1 - K)}{f_2 + f_1 (1 - K)}, \qquad (5a)$$

and Equation 6 becomes

$$\mathrm{EFL} = \frac{f_1 f_2}{f_2 + f_1 (1 - K)}. \qquad (6c)$$

The over-all length of the system, from the first lens to the focal plane, is $L = \mathrm{BFL} + t$. Setting up the ratio of over-all length to EFL, we obtain

$$\frac{L}{\mathrm{EFL}} = 1 + K\frac{f_1}{f_2}(1 - K). \qquad (7)$$

Since K is necessarily positive and less than unity, the second term will be negative if f_2 is negative, and the ratio L/EFL will be less than unity. Thus we have a lens that takes up an axial space less than its equivalent focal length, which is the characteristic of a telephoto lens. The reason for this peculiar geometric property of a telephoto lens is that its principal planes are located outside of the positive lens.

If the telephoto arrangement is used in reverse it provides a BFL greater than the EFL. While this does not represent any particular type of instrument, it is often a useful scheme in optical systems.

A Galilean or erecting telescope (Fig. 12D) will result if t is increased to $t = f_1 + f_2$. Field glasses are often of this construction. Still greater values of t are of little practical importance.

E. Magnification of an Instrument

In July, we defined **linear** magnification as the ratio of the sizes of image and object. This useful concept applies directly to instruments like projectors. But magnification obviously means something quite different for telescopes and microscopes. Here we are interested in how large the object **appears** when seen in the instrument compared to how large it appears when viewed without the instrument. This is **angular** magnification, since when we talk about how large an object appears we are talking about the angle it subtends.

Consider a single lens forming an image of an object, as in Fig. 13A. The angular size of the object is θ, and since the ray **POP'** is straight and passes through both the object and image points, it follows that the angular size of the image (as seen from the lens) is also θ. In other words, there is no angular magnification produced

by a single image formation. There is, of course, the linear magnification mentioned above.

Now suppose that we use this same lens as a simple magnifier. This means that we place the object at the focal point of the lens, forming a virtual image at infinity (Fig. 13B). This is how a magnifier should be used. It is also possible to use it as shown in Fig. 13C to form a relatively close virtual image, and probably a magnifier is often used in this way. But then

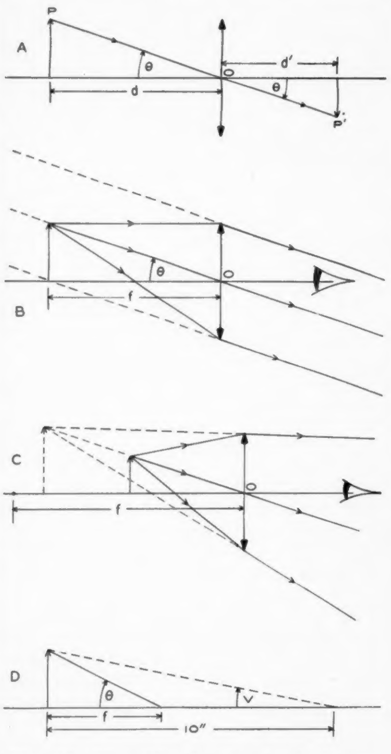

Fig. 13. Magnification in simple image formation is shown in A. Ideal and non-ideal use of a simple magnifier are illustrated by B and C. The relation between angular size and magnification for a simple magnifier is shown by D.

the conclusions we are about to draw would not be strictly true.

Assuming that the magnifier is used ideally, with a virtual image at infinity, the angular size of the image is θ. By definition, the magnification will be the ratio of θ to the angular size of the object viewed without the magnifier. This latter size obviously depends on the location of the eye, so we must adopt a standard. Were the eye placed at point O (Fig. 13B), the magnification would be unity and there would be no advantage in using the magnifier. For any magnifier, however, the focal length is so short that the unaided eye could not see the object clearly from such a short distance. The essential function of a magnifier is to bring the eye effectively closer to the object than the limited power of accommodation would otherwise allow. Hence we adopt as our standard observation distance 10 inches, the average near point of distinct vision of the normal human eye.

When using the magnifier the eye is

effectively located at **O**, the effective viewing distance is **f**, and therefore the magnification will be

$$m = 10/f, \quad (8)$$

where **f** is expressed in inches.

From Fig. 13D it is seen that the angular magnification in terms of the angular sizes is

$$m = \tan \theta/\tan V, \quad (8a)$$

where θ is the angular size of the image (or object as seen from the lens) and **V** is the angular size of the object viewed directly from a distance of 10 inches.

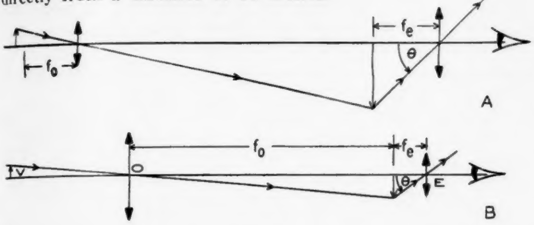

Fig. 14. The upper diagram shows magnification by a compound microscope; the lower, the manner in which a telescope magnifies.

A compound microscope consists of an objective, which forms a real image of the original object, and an eyepiece for viewing this image, as shown in Fig. 14A. The eyepiece is in principle merely a simple magnifier, to which the simple-magnifier rules apply directly. Accordingly, microscope eyepieces are customarily marked 10x, 25x, and so on, in accordance with the ratio 10/**f**.

To obtain the magnification of a compound microscope, clearly we must multiply the magnification of the eyepiece, considered as a simple magnifier, by the **linear** magnification of the objective. This is because we are using the eyepiece to observe an image which is already **M** times larger than the original object, when **M** is the linear magnification of the objective.

However, **M** is a function of the object and image distances, which depend in turn on where we place the objective; hence the linear magnification is not an inherent property of the objective. It is standard practice in microscopes to hold the objective-image distance constant (called tube length by the manufacturers), and the objective is marked with the corresponding linear magnification. This number, engraved on the barrel, is multiplied by the angular magnification marked on the eyepiece to give the magnification of the microscope. Objective magnifications customarily run from 5x to 100x, eyepieces from 10x to 25x.

A simple telescope offers the same situation of a real image formed by an objective and viewed through an eyepiece (Fig. 14B). Since in this case the original object is at infinity, the concept of linear magnification does not apply. So we go back to Equation 8a, where **V** is now the angular size of the object seen by the objective, which is the same as its angular size seen by the eye. When the object is at infinity, no standard distance is necessary. It is clear from Fig. 14B that the ratio of the tangents is the inverse ratio of the focal lengths of objective and eyepiece, so that we have for a telescope:

$$m = -f(o)/f(e) \quad (9)$$

The negative sign comes from the fact that θ and **V** are measured in opposite directions, hence their tangents are opposite in sign. The sign of **m** is important, because it tells us whether the final image is erect or inverted.

(To be continued)

OBSERVER'S PAGE

Universal time is used unless otherwise noted.

The Visibility of the Planets in Late Fall

THE TRANSIT of Mercury on November 14th heralds the simultaneous appearance of the five bright planets in the morning sky. It is an especially favorable configuration for observers in the Northern Hemisphere in view of the high inclination of the ecliptic to the horizon at this season.

The accompanying diagram is patterned after the Graphic Time Table of the Heavens (**Sky and Telescope,** January, 1953). From it one can tell how long each of the planets from Mercury to Saturn will have been above the horizon by sunrise, at 40° north latitude. Uranus, Neptune, and Pluto will also be in the sky at this time.

Mercury should be visible in the morning twilight by November 20th, when it rises about an hour in advance of the sun. The unusual array will continue until December 23rd, when Jupiter sets as Venus rises. The moon is also on the scene for two weeks beginning on November 20th, when it sets just before sunrise, and ending on December 4th, when it is last visible as a slender waning crescent near Mercury and Venus.

This configuration of planets coincides with the appearance of the maximum number of 1st-magnitude stars that can be seen at any one time in mid-northern latitudes. In the western sky, Jupiter will be in the midst of the array of stars so familiar on a winter's night: Rigel, Betelgeuse, Aldebaran, Sirius, Procyon, Pollux, and Capella. Regulus will be near the meridian, while Arcturus and Spica will be in the east. Vega will shine low in the northeast.

During the hour and six minutes from the rising of Vega until the setting of Rigel, the 11 stars named will all be visible. At more southerly latitudes, this interval will be less until, at 26° 16' north, the two stars will be on the horizon simultaneously. This is because the change to more southerly latitude retards the rising of Vega more than it delays the setting of Rigel.

For observers in the northern United States, another 1st-magnitude star will be visible. At 40° north, Deneb rises about five minutes before Rigel sets; the two appear simultaneously on the horizon at 39° 34' north. Furthermore, Deneb rises so far north that it gains in altitude very slowly. Accordingly, its time of lower transit, rather than that of rising, is drawn on the chart, but the star itself can be seen at lower transit only by observers north of 44° 19'. As Deneb is much less brilliant than Vega and Rigel, better atmospheric conditions will be required to detect it near the horizon than to see the two brighter stars.

The best time for simultaneous observation of all these stars and planets is about November 28th. On that morning, the moon will be at last quarter and located high in the southern sky a little southeast of Regulus.

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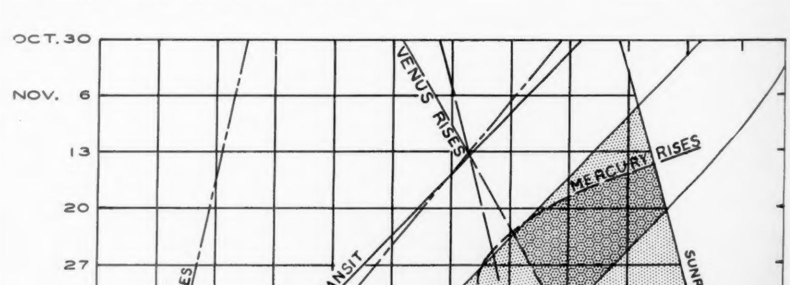

The shaded area between the lines marked Vega Rises and Rigel Sets shows the times when 11 1st-magnitude stars will be simultaneously above the horizon before sunrise, for the dates at the left. The circumstances when all five bright planets can be seen at once are given by the shaded area between the Venus Rises and Sunrise lines, further bounded by the Mercury Rises and Jupiter Sets lines. The heavily shaded area indicates when all 16 objects are above the horizon together, in the morning twilight.

Photography of the Canals of Mars

THE APPROACHING favorable oppositions of Mars in 1954 and 1956 call for a concerted effort to photograph the fine detail of its surface. Oppositions when the diameter of Mars is less than 20 seconds of arc come when the observing conditions are unfavorable in the Northern Hemisphere: autumn, winter, and spring. In 1954 and 1956 the diameters will reach 22 and 25 seconds and exceed 20 seconds for 47 and 84 days, respectively. In 1958 and 1969 the Martian diameter will be about 19 seconds.

To be photographed, the canals of course must be present, and this depends on the Martian season. From what we know now, the canal system depends most closely on the seasons of the southern hemisphere, but to what degree it is connected with the northern seasons we are still in doubt. Very few canals are visible during the south Martian late summer, autumn, and winter. They first appear satisfactorily about Martian April 1 (northern style season) and by the middle of June little is left of them.

The table shows the relation of terrestrial dates of oppositions to Martian seasons and canal visibility. It will be

Seasonal Dates on Mars at Opposition

*Martian Seasonal Dates**	*Terrestrial Dates* 1939	1954	1956
Feb. 15	Mar. 28	Apr. 15	Mar. 1
Mar. 1	Apr. 25	May 12	Mar. 28
Mar. 15	May 21	June 6	Apr. 22
Apr. 1	June 18	*July 6§*	May 23
Apr. 15	*July 12†*	*July 28*	June 14
May 1	*Aug. 6‡*	*Aug. 23*	*July 9*
May 15	*Aug. 27*	*Sept. 14*	*July 29*
June 1	*Sept. 23*	Oct. 9	*Aug 25*
June 15	Oct. 12	Oct. 30	*Sept. 15¶*
July 1	Nov. 9	Nov. 25	Oct. 14
July 15	Nov. 29	Dec. 16	Nov. 3

*Martian seasonal dates are the terrestrial dates when the sun has the same longitude as that measured on Mars from its autumnal equinox. The dates in the middle of the table are in the Martian season when the canals develop, reach maximum visibility, and decay. The dates in italics are when the best seeing can be expected in the earth's north temperate zone.

† Canals first seen by the author July 6, 1939.
‡ Maximum diameter 24", July 28, 1939.
§ Maximum diameter 22", July 2, 1954.
¶ Maximum diameter 25", Sept. 8, 1956.

seen that the Martian season of canal visibility coincides with the months of terrestrial good seeing. It may be that the time of first visibility is sometimes influenced by the prevailing seeing conditions. The period when the whole canal pattern can be seen in moments of superseeing, between Martian April 20 to May 20, usually occurs in terrestrial July and August, but in 1956 it comes as early as mid-June.

The observing conditions required for photography successfully to reveal the whole pattern require a degree of atmospheric stability not detected by ordinary examination of a stellar image. If in common good seeing we put the eye at the stellar image and view the illuminated objective, it is crossed by parallel waves moving laterally in some position angle determined by the air flow. If we examine Mars, only one or two canals will show running in approximately the same position angle as the air flow. If the seeing improves, the waves diminish in amplitude and speed, and there may be moments when they cannot be seen. These are the moments of superseeing when the whole canal pattern can be seen on Mars.

If we look at the planet as these moments of superseeing approach, we see the canals first singly, then in increasing numbers simultaneously, and then the whole pattern appears, enduring only a second or two. The longest the writer has seen the whole pattern was four or five seconds. The disappearance is in reverse order. The whole period of visibility, which is usually only 15 or 20 minutes, may be repeated at intervals that night, but it may not be.

These moments of superseeing may arrive at any elevation of the planet. The writer has seen the pattern from Mount Wilson with the 20-inch reflector at declination —25°, hour angle 2^h, air mass 2.4. If diaphragming the telescope improves the seeing, the seeing is probably not good enough for the pattern to appear. The atmospheric conditions are of utmost importance, no clouds anywhere, temperature changes very slight, and no perceptible wind. An anemometer is a useful aid in observing, for it will not rotate at times of superseeing. Any wind will surely blot out the canals for photographic purposes. In my experience the intervals of superseeing all came after midnight.

The image size adopted for photography with fine-grain emulsions such as Eastman Kodak Plus X is of the order of 8 mm. The widths of canals are unknown, but are generally regarded as of the order of one areographic degree, or 0".2 at favorable opposition. On a picture of 8-mm. diameter they would be 0.07 mm., 20 to 30 silver grains, wide near the center of the disk. This means an equivalent focal length of 226 feet for an image 24 seconds in diameter.

Arrangements for multiple exposures must be made and for that purpose a motion-picture camera is well suited. A motion-picture camera has been prepared to be attached to the 100-inch telescope at the coude focus. The camera is driven by a motor through variable speed drive and friction clutch which is detained by a magnet-operated latch. Exposure times of 1/10 second to one second can be made and the interval can be made any fraction of a minute; or the camera may be operated automatically at intervals of a fraction of a second. A filter slide with yellow and blue filters is provided. Exposures in yellow and blue light are 0.1 and 0.2 second, respectively. A step wedge can be inserted for calibration. The blue exposures will be taken to check the blue-clearing discovered by E. C. Slipher. The instrument can be swung to one side for knife-edge focus on a star.

Several idiocrasies of the canal system make its study desirable: (1) While most of the system is in the northern hemisphere, it seems to be closely associated with the seasons of the southern. Less is known of the canals at north polar presentation, but the few that have been seen are also seen in the south polar presentation, so far as is known. It may be that the northern spring does produce the canal pattern, but our seeing conditions and the small planetary image have prevented these difficult observations. This is a good problem for observatories in our Southern Hemisphere. (2) The temperature on Mars at perihelion at noon in the tropics is 80° F., but at aphelion it is only 34° F., yet the writer saw parts of the canal system with the 60-inch on February 7, 1946 (diameter 13"), when the tropical noon temperature could not have been more than 36° F. The Martian seasonal date for the northern hemisphere was then April 27.

The limb temperatures at points $3^h\ 40^m$ from the Martian meridian at perihelion and at aphelion are 43° F. and 16° F., respectively, yet canals are seen near the tropical limb at both positions of the planet.

Mars has an atmosphere only 1/15 as dense as ours and no water vapor has been detected. The absence of water vapor is evident since the atmosphere produces no blanketing effect on the radiation from the planet. Kuiper's observation of bands due to water in solid or liquid state in the infrared spectrum of the pole caps seems to identify some water on the planet, and the seasonal connection of the pole caps and canals would reasonably indicate a transfer of water. On the other hand, the night temperature must be extremely low, so that any free water would be frozen solid long before sunrise. We often see frosty spots at either limb, but the canals appear with their green color as soon as rotation brings them well past the limb. One cannot now make a reasonable conjecture as to the constitution of the canal structure on Mars, and it is to be hoped that additional observations, particularly of a photographic nature, will be obtained in 1954 and 1956.

EDISON PETTIT
Mount Wilson and
Palomar Observatories

Reprinted by permission from the *Publications* of the Astronomical Society of the Pacific, August, 1953. The paper was given at the June meeting of the society in Santa Barbara.

LUNAR ECLIPSE OBSERVED

The total eclipse of the moon on July 26th was successfully observed in the Far West. At Woodside, Calif., although a foggy night had been predicted, Lou Goodman was able to observe the eclipse in exceptionally clear skies. He took pictures through a 6-inch f/12 reflector, exposing for ⅛ second with a Leica camera placed at the focus.

At Salem, Ore., Carl P. Richards got up at two o'clock in the morning, drove a few miles out of town toward the airport for a clear horizon, and was rewarded with a perfectly clear sky. He took a series of photographs on one film, showing the successive stages of obscuration of the moon. When the eclipse became total, the moon was only 10 degrees above the western horizon and, consequently, it was additionally reddened by the increased absorption of the atmosphere at that low altitude.

When the moon could no longer be photographed, Mr. Richards turned his camera to the east to record Venus and Jupiter above the light of the dawn.

Leon E. Salanave, lecturer in astronomy at the Morrison Planetarium, San Francisco, set up a camera on the western slope of Mt. Diablo, 2,900 feet above sea level. There he secured an excellent series of photographs of the moon, including some showing the difference in penumbral and umbral darkening near the time of first contact with the umbra.

At Pasadena, Calif., the immersion of an unidentified star was noted at about 11:26 UT near the moon's northern edge, by R. J. Schussler, Jr. He photographed the eclipse with a 35-mm. camera at the eyepiece of a 6-inch reflector. Eastman Kodak Plus X film was used at 1/50 second exposure. The eclipse was observed under good conditions until it was lost in the early morning haze near the horizon.

THE VISIBILITY OF NEBULAE

The true nature and extent of nebulosities are revealed on photographs only by a deliberate exaggeration of contrast. For instance, a picture of the Triangulum nebula, M33, usually appears as a bright pinwheel on a black background, and this is in such contradiction to the telescopic appearance that the visual observer, discouraged, may underestimate what can actually be seen. Thus, few seem aware that the Veil nebula in Cygnus is visible in good binoculars.

Can Barnard's dark nebulae be recognized visually? I tested this recently on an expedition to Mt. Toxaway, N. C., altitude 4,700 feet, to measure the relative darkness of Barnard's objects with a 1P21 photomultiplier on a 4-inch refractor.

Five-inch Japanese binoculars with coated optics were used to examine Barnard's well-known S-shaped dark nebula near Theta Ophiuchi. This had often been looked for unsuccessfully in Decatur. In the clear mountain air, miles from city lights, no trace of the S could be seen. Has anyone ever seen this? M31 was stretched completely across the 3° field of the binoculars.

W. A. CALDER
Agnes Scott College
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1954 GRAPHIC TIME TABLE

Next year's Graphic Time Table of the Heavens is now available. This earlier publication date will be advantageous to amateurs and teachers who are planning observations or visits to observatories beyond the current year. The scale has been carefully preserved, so that joining the charts end to end gives a complete picture of the transition of events from one year to the next.

The 1954 chart was published in time for distribution at the Washington, D. C., convention of the Astronomical League. Carroll F. Merriam, vice-president of the Maryland Academy of Sciences, there exhibited wall-sized charts to show how the Time Table may be readily adapted to any latitude, 45° north to 45° south.

As usual, the Maryland Academy of Sciences will permit **Sky and Telescope** to reprint the original plate on the center pages of the forthcoming January issue, but copies of the 1954 Graphic Time Table may be secured immediately from Paul S. Watson, curator of astronomy, Maryland Academy of Sciences, 400 Cathedral St., Baltimore 1, Md. Single copies are 25 cents each, the same as formerly, 15 cents each for orders of 20 or more. The 1953 and 1954 editions together are 30 cents for the pair, and 20 cents in orders of 20 or more.

PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

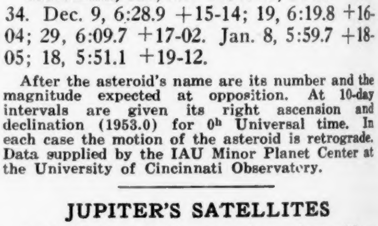
Urania, 30, 9.5. Nov. 29, 6:28.5 +25-55. Dec. 9, 6:19.6 +25-56; 19, 6:08.6 +25-52; 29, 5:57.1 +25-42. Jan. 8, 5:46.9 +25-27; 18, 5:39.4 +25-07.

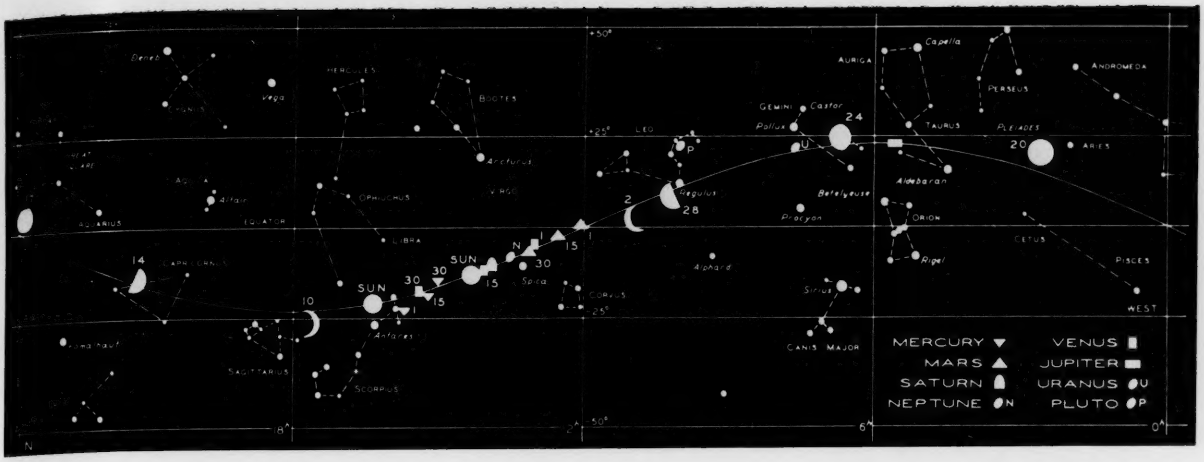
Herculina, 532, 9.6. Nov. 29, 6:35.9 +14-34. Dec. 9, 6:28.9 +15-14; 19, 6:19.8 +16-04; 29, 6:09.7 +17-02. Jan. 8, 5:59.7 +18-05; 18, 5:51.1 +19-12.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1953.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the Universal time given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the American Ephemeris and Nautical Almanac.





THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury can be observed during three different periods in November. The first few days of this month it may be seen with difficulty low in the southwest as a +0.5-magnitude object about 9° west of Antares, setting three quarters of an hour after the sun.

The first transit of Mercury in 13 years occurs on Saturday, November 14th, and may be observed throughout the Western Hemisphere. The Universal times of ingress and egress are approximately 15:37 and 18:12, respectively, for all locations. A telescope will be necessary to see Mercury on the sun's disk. Detailed information on the transit is given in the October issue.

Mercury becomes visible in the morning sky the last week of November, with greatest elongation occurring December 1st. On November 23rd it will be at magnitude +0.7, and located 1° 12′ north of the much brighter Venus. On that date both planets will rise together over an hour before the sun. (See the special article on the visibility of all the bright planets in the morning sky this month.)

Venus rises as morning twilight commences in mid-month, appearing at magnitude —3.4. Venus passes three planets in conjunction during November: on the 7th at 7^h UT Neptune will be 7′ north; Saturn appears 52′ north of Venus on the 14th at 4^h; the conjunction with Mercury on the 23rd is described above. On the 15th the diameter of Venus will be 11″, with 95% of the disk illuminated.

Mars, also a morning object, rises 3½ hours before the sun in mid-November. It is an inconspicuous 2nd-magnitude object, moving through Virgo west of Spica.

Jupiter, the only naked-eye planet visible during evening hours, rises about 1½ hours after sunset on the 20th. This brilliant planet, of magnitude —2.3, is in retrograde motion in eastern Taurus preceding opposition next month. The equatorial diameter of the disk will be 46″ in mid-November.

Saturn reappears in the morning sky early this month not far from Venus, passing 52′ north of it on the 14th.

Uranus may be observed with slight optical aid from early evening for the remainder of the night. This distant 6th-magnitude planet is in retrograde motion about 3° south of Kappa Geminorum.

Neptune is between Saturn and Mars in the morning sky all month. In late November it will be about 1° west of 82 Virginis.

E. O.

VARIABLE STAR MAXIMA

November 1, R Leonis Minoris, 093934, 7.2; 2, RU Sagittarii, 1951**42**, 7.2; 3, T Normae, 1536**54**, 7.4; 3, T Aquarii, 2044**05**, 7.9; 7, RS Librae, 1518**22**, 7.7; 7, W Ceti, 2357**15**, 8.2; 9, R Bootis, 143227, 7.3; 14, T Columbae, 0515**33**, 7.6; 15, RV Centauri, 1331**55**, 7.6; 23, R Draconis, 163266, 7.6; 28, RT Cygni, 194048, 7.4.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

MOON PHASES AND DISTANCE

New moon	November 6, 17:58
First quarter	November 14, 7:52
Full moon	November 20, 23:12
Last quarter	November 28, 8:16
New moon	December 6, 10:48

	November		Distance	Diameter
Apogee	3,	2^h	252,200 mi.	29′ 26″
Perigee	18,	23^h	225,200 mi.	32′ 58″
Apogee	30,	18^h	251,600 mi.	29′ 31″
	December			
Perigee	16,	14^h	228,700 mi.	32′ 28″

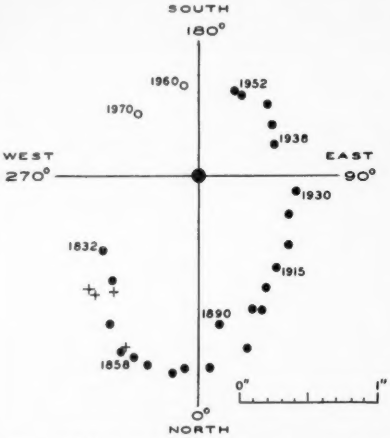
MINIMA OF ALGOL

November 1, 1:57; 3, 22:45; 6, 19:34; 9, 16:23; 12, 13:12; 15, 10:01; 18, 6:50; 21, 3:39; 24, 0:28; 26, 21:17; 29, 18:06. December 2, 14:55.

These minima predictions for Algol are taken from the 1953 **Handbook** of the Royal Astronomical Society of Canada.

DEEP-SKY WONDERS

IF the reader owns a copy of the fourth edition of Webb's **Celestial Objects for Common Telescopes,** he will read that the double star 36 Andromedae is "beautiful but not difficult." The data cited there from Dembowski are position angle 356°, separation 1".3, magnitudes 6.2 and 6.8, which suggest a neat and easy double, something that might exercise a 4-inch telescope, perhaps. But if in 1953 the observer settles on this pair, he will need a 10-inch to see the companion clearly, for it has now moved halfway around its orbit and crept in to less than half its previous distance. It is now at 170°, 0".6, and difficult.



The orbital motion of the binary star 36 Andromedae. The primary is at the center of co-ordinates. The open circles are predictions of the companion's position for 1960 and 1970.

The pair is another illustration of Aitken's rule that a reliable orbit cannot be computed until the observations cover both ends of the apparent ellipse. The early period determinations, 349 years by Doberck (1872) and 109 years by Rabe (1914), were very rough, because the motion since discovery by Struve in 1832 was still too small. The three most recent periods, in contrast, agree well. Van den Bos (1938) found 169 years, Baize (1946), 166 years, and Rabe again (1951), 153 years.

The crosses on the orbit plot are the measures by Admiral Smyth noted in his **Bedford Catalogue.** As they stand they do not look too bad, but when position angle and distance are plotted against time in separate diagrams, it is clear that Smyth's position angles are all too large by about five degrees, and his distances tend to be too great.

In coming years the position angle of 36 Andromedae will be increasing rapidly, while the separation remains nearly unchanged, as the following ephemeris based on Baize's orbit shows.

Year	Position Angle	Separation
1950.0	155°.7	0".65
1954.0	169.3	0.66
1958.0	182.6	0.66
1962.0	196.3	0.65
1966.0	210.4	0.64
1970.0	225.4	0.63

WALTER SCOTT HOUSTON

OCCULTATION PREDICTIONS

November 8-9 **Alpha Scorpii** 1.2, 16:26.5 —26-19.8, 2, Im: **A** 17:50.6 —2.0 0.0 97; **B** 17:48.7 —1.9 +0.1 94; **C** 17:41.1 —2.1 0.0 106; **D** 17:37.4 —1.8 +0.3 100; **E** 17:17.2 —1.4 +0.2 118; **F** 17:14.0 —0.4 —1.4 152. Em: **A** 19:18.6 —2.0 —0.7 277; **B** 19:14.4 —1.8 —0.7 281; **C** 19:11.0 —2.2 —0.4 272; **D** 19:04.2 —2.0 —0.4 278; **E** 18:39.7 —2.2 +0.4 268; **F** 18:13.5 —3.0 +1.8 241.

November 14-15 **Theta Aquarii** 4.3, 22:14.4 —8-01.1, 8, Im: **A** 3:48.7 —0.4 —0.2 54; **B** 3:48.1 —0.3 +0.1 44; **C** 3:47.2 —0.6 —0.3 62; **D** 3:45.7 —0.4 +0.1 45; **E** 3:37.8 —0.7 +0.5 42; **F** 3:26.8 —1.3 +0.4 57; **H** 3:17.0 +0.5 +3.5 354.

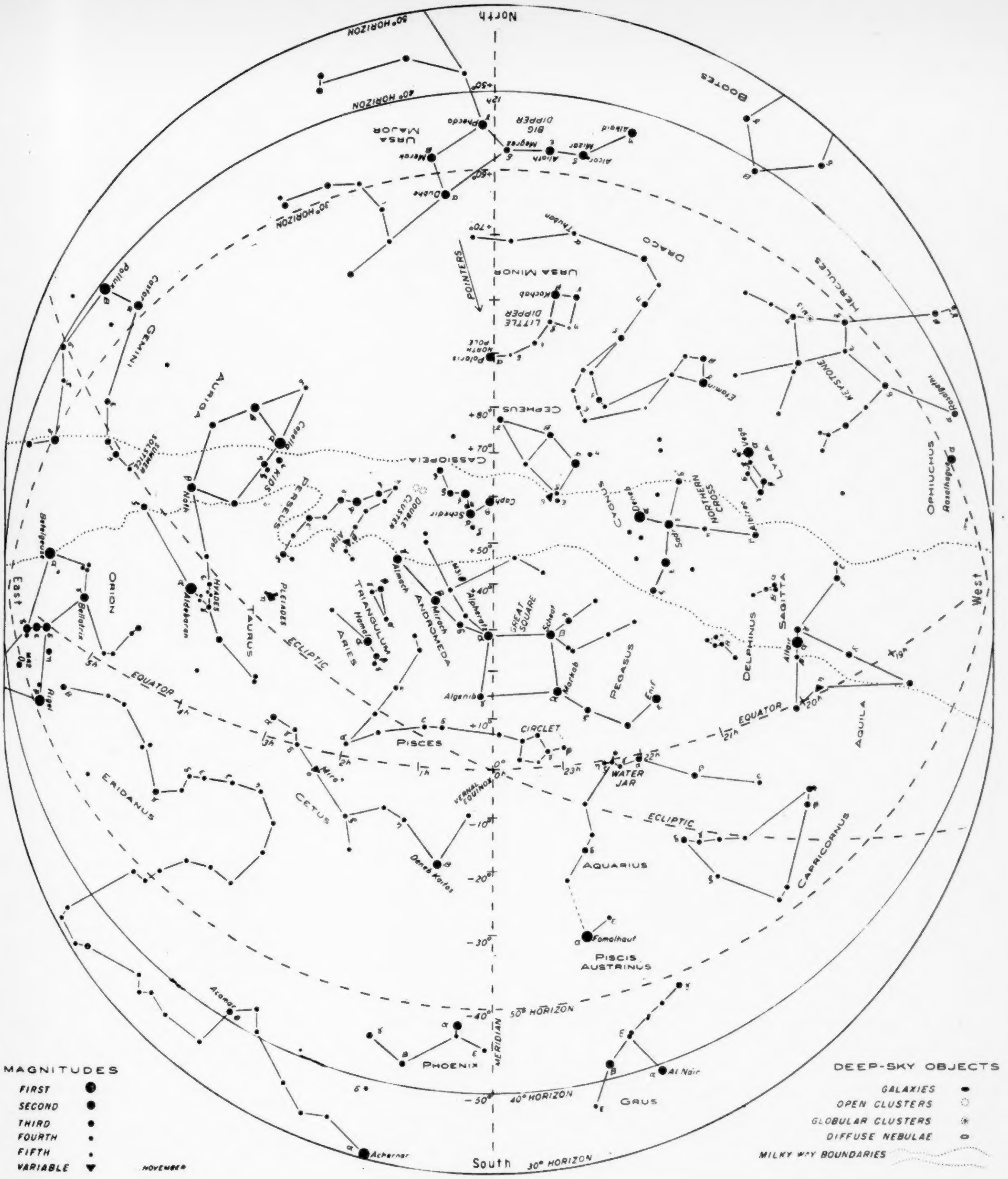
For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, data from the **American Ephemeris** and the **British Nautical Almanac** are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo,** lat. **L**) within 200 or 300 miles of a standard station (long. **LoS,** lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5		**E** +91°.0, +40°.0	
B +73°.6, +45°.6		**F** +98°.0, +31°.0	
C +77°.1, +38°.9		**G** +114°.0, +50°.9	
D +79°.4, +43°.7		**H** +120°.0, +36°.0	

I +123°.1, +49°.5



The sky as seen from latitudes 30° to 50° north, at 9 p.m., and 8 p.m., local time, on the 7th and 23rd of November, respectively.

STARS FOR NOVEMBER

AGAIN in this volume, as during 1948, the simplified black-on-white **Sky and Telescope** star charts will be reproduced, for the benefit of amateurs just starting their study of the constellations. These are based on the same master maps as our regular white-on-black charts, but considerable detail has been eliminated for greater clarity and ease of use where the bright constellations are concerned.

Nevertheless, there is enough detail on the simplified charts to keep the beginner busy for some time. All the ancient and important constellations are retained, together with the names of the brightest stars. Greek letters for these are also shown, but only for the first seven in any large constellation; these letters are: alpha (α), beta (β), gamma (γ), delta (δ), epsilon (ε), zeta (ζ), and eta (η), illustrated by the stars of the Big Dipper. The letter omicron (o) is used once, for the variable star Mira, in the constellation of Cetus, the Whale.

The hours of right ascension are marked along the equator, and degrees of declination are on the meridian line. The Milky Way boundaries are indicated, and the equinoxes and solstices labeled. The brightest of the so-called deep-sky objects, of particular interest to the amateur with a field glass or small telescope, have been retained. On this November chart, the naked-eye Andromeda nebula, M31, has been plotted, as are also the Double Cluster in Perseus, the Pleiades in Taurus, and the great globular cluster in Hercules.